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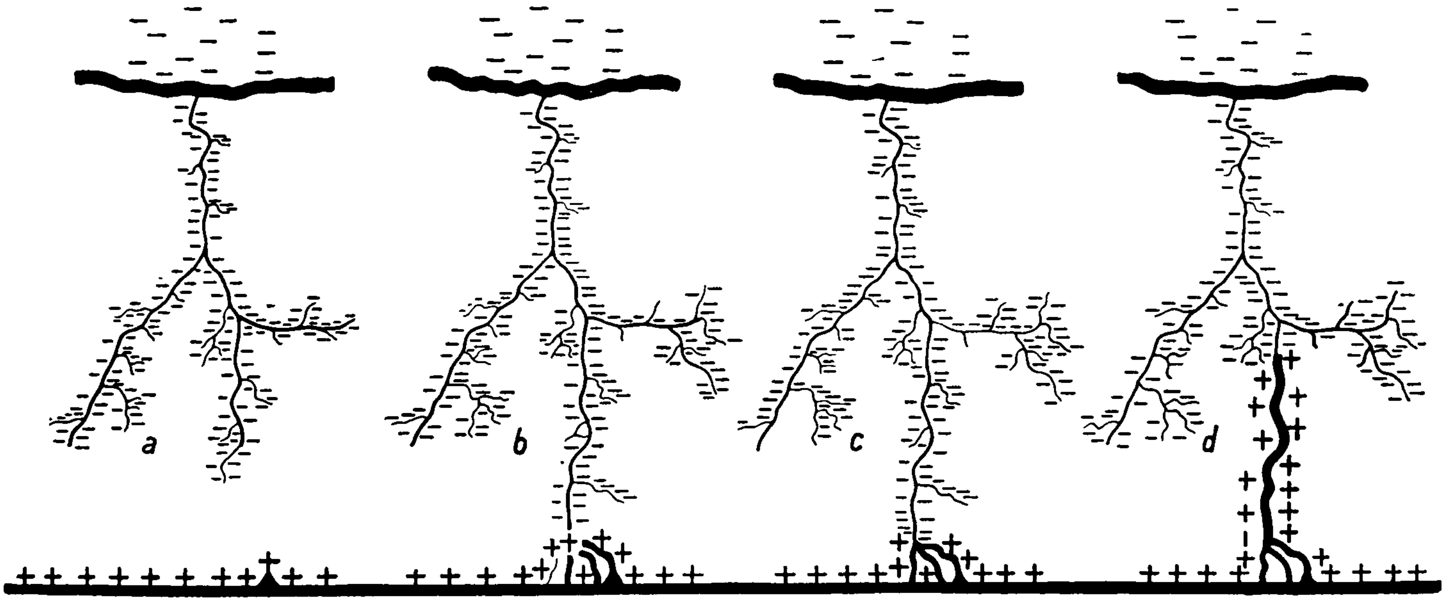

FIG. 1.—DEVELOPMENT OF A LIGHTNING FLASH

Reproduced from the Halley Lecture, 1937

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The Lightning Discharge*

The Halley Lecture delivered on 28*th May*, 1937, *by Professor B. F. J. Schonland*

There are few problems in meteorology more fascinating than that of the thunderstorm. It is a many-sided problem: how is the electricity generated; what part does the precipitation play; where does the lightning originate; what exactly takes place in the lightning discharge?

Professor B. F. J. Schonland and a band of enthusiastic workers in South Africa have attacked the last of these problems with remarkable success, and it was very appropriate that when he was invited to deliver the Halley lecture at Oxford, last year, he should make "The Lightning Discharge" the subject of his discourse.

Many workers, in particular Professor B. Walter of Hamburg, have used a moving camera as a tool in the study of the lightning flash, but they were always up against two difficulties: first, with a rotating camera it is difficult to obtain sufficient speed to separate out the rapid changes, and secondly it is not possible to separate changes due to time and changes due to the non-linear shape of the discharge channel. Both these difficulties were overcome by Professor (now Sir) Charles V. Boys by means of a stationary camera fitted with two lenses attached to the ends of a rapidly rotating arm. With this camera it is possible to determine with great exactitude the time sequence of points on the image of a lightning flash, intervals of a few micro-seconds being easily measured. Boys, having proved the success of his camera, but despairing of ever being able to use it in this country except on very rare occasions, presented it to Schonland to use in South Africa where thunderstorms are more frequent and the flashes are less obscured by low clouds. Seldom has such generosity been more amply repaid.

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* B. F. J. SCHONLAND, O.B.E., M.A., Ph.D. The lightning discharge, being the Halley Lecture delivered on 28 May, 1937. Size 9 in. × 5¾ in., pp. 19. *Illus.* Oxford, at the Clarendon Press, 1938. 2*s*. net.

The Halley lecture itself was a condensed summary of six years' work; it is therefore clear that in a short article like this it is only possible to give the broadest outline of the conclusions reached; the lecture itself, or better still the original papers in the *Proceedings of the Royal Society,* must be consulted for details.

A lightning flash when viewed by the naked eye appears to consist of a channel more or less branched extending from the cloud to the ground; usually the flash appears as an instantaneous discharge, but occasionally it appears to remain for a sensible time and sometimes actually to flicker. The moving camera showed that the luminosity does in fact persist for an appreciable time and that not infrequently after one discharge has passed, another discharge uses the same channel. This may be repeated several times, thus accounting for the flicker. Walter, using a camera rotating at a steady speed about a vertical axis, was able to measure these times and to record the number of discharges which passed down the same channel before it disappeared. It is usual now to speak of the whole series of discharges along the same channel as a "lightning flash" and to describe the individual discharges as "strokes" or "partial discharges".

The outstanding result of the work in South Africa has been to show that every lightning flash is preceded by a leader stroke which opens up a channel between the cloud and the ground and it is only when this leader stroke reaches the ground that the main highly luminous discharge travels upwards from the ground to the cloud. The leader stroke, which is nearly non-luminous, cuts its way through the air in a series of short advances or steps and may be highly branched. The return streamer starting where the leader strikes the ground passes upwards along the channel left by the leader and along each of the branches so that the whole track of the leader stroke is marked out in brilliant light. The whole process is shown diagrammatically in Fig. 1, reproduced from Schonland's lecture. The base of the cloud is shown by a heavy line and it is here that the flash first becomes visible; but it is important to remember that the flash does not start *on* the cloud but *within* the cloud and it may have travelled for a kilometre or two within the cloud before appearing below the cloud.

Starting then within the cloud the leader stroke first appears as it leaves the cloud and moves downwards at a rate of about 200 km./sec.; at *a* of Fig. 1 it is shown when it has progressed some distance towards the earth. The whole channel is conveying negative electricity which it distributes into the air along the branches. At first the direction of the path and the points of branching are determined by fortuitous conditions at the end of each branch and not at all by features on the surface of the ground. When, however, the tip of the longest branch approaches the ground as at *b*, very strong electrical fields are set up between the end of the channel and the ground. From irregularities on the ground, positive electricity streams out to meet the negative electricity in the approaching channel. Contact is made between the channel of the leader and the channels from the ground and the first part of the flash is over—see *c*.

The leader stroke has not only conveyed a large amount of negative electricity from the cloud and left it in all its channels; but those channels are highly conducting. In fact at the moment that the leader stroke reaches the ground the conditions are almost as though a wire had been stretched between the negative charge within the cloud and the induced positive charge on the earth. Along this channel positive electricity from the ground passes upwards to meet and neutralise the negative electricity in the branches and in the cloud. This process takes place at a rapid rate, the positive electricity moving upwards at 20,000 km./sec.; i.e., 100 times as fast as the leader stroke moved downwards. The current carried by this return streamer is very great and causes intense luminosity in the channel. This is the stage of the process which produces the blinding light of a lightning flash. As soon as the positive electricity has reached the upper end of the channel, which is well within the cloud, the flow ceases and the luminosity of the channel fades away. The air in the channel, however, remains in the conducting (ionized) state for a relatively long time after the glow has ceased to be visible.

In most cases this is the end of the lightning flash; but occasionally the whole process starts again almost immediately. According to a later paper by Schonland this is due to a discharge starting from another portion of the cloud. According to this explanation a new leader starts, but it does not travel towards the ground but towards the end of channel left by the previous stroke. On reaching the top of the channel it finds a conducting path reaching down to the ground and naturally it follows this path rather than blaze out a new path through the air. Owing to the use of the conducting channel this second leader stroke is able to travel faster than the first, its velocity being 2,000 km./sec., i.e., 10 times faster than the first leader but still only a tenth of the velocity of the return streamer. This second leader stroke travelling down the old channel does not use the branches, but only the main path to earth, so that strokes subsequent to the first one are not branched. On reaching the ground it releases a second return streamer which again illuminates the channel from earth to cloud. This process of leader followed by return streamer may be repeated many times—in another paper Schonland says that as many as 40 successive strokes have been observed.

There is not space here to refer to a number of other points dealt with by Schonland in his interesting lecture but the following typical timetable may be of interest. The leader stroke takes about ·01 sec. to travel from the cloud to the ground and the return stroke ·00004 sec. to reach the cloud and probably twice as long to reach the end of the channel so that the luminosity lasts less than one ten thousandth of a second. If there are subsequent strokes along the channel the total duration of the flash may well extend to a tenth of a second and in extreme cases to a whole second.

The work done by Schonland and his colleagues has been very great and so thorough that full reliance can be placed on the conclusions reached. At the same time only a very small portion of the problem of the lightning discharge has been touched. All the flashes investigated in South Africa have been discharges from a negatively charged cloud to earth. There is still the problem of the discharge of a positively charged cloud which must be entirely different and probably takes place without a leader. Then there is the problem of where and how the discharge commences. There is reason now to believe that this is always within the cloud but it is not known whether the primary discharge is between two differently charged cloud layers and the flash to earth only a secondary effect. Then there is the final problem of the strength of the field necessary to initiate a discharge. The Bernard Price Institute of Geophysics at Johannesburg has been founded largely to carry out these investigations under the direction of Professor Schonland and we wish him and his co-workers all success.

G. C. SIMPSON.

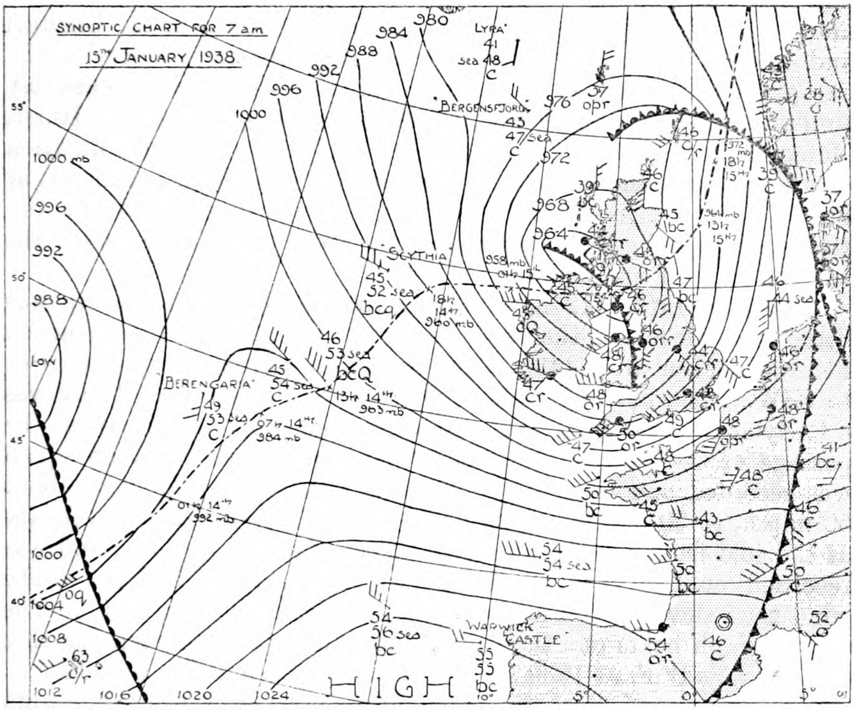
The Gale of January 14th–15th, 1938

BY F. H. DIGHT, B.SC., A.INST.P.

Intensely cold weather over practically the whole of the continent of Europe had, for a lengthy period, both before and after Christmas 1937, almost continuously threatened at least the southern half of Britain with a spell of really cold weather. The intrusion of the milder conditions from the south-west just before Christmas for a time suggested that a complete change of type might result, but the year closed with the mainly quiet conditions which had characterised the autumn, still persisting. It was about a week later that the "westerlies" were finally established and local gales occurred chiefly round the south-western coasts. By January 11th the further change to a mild stormy type of weather with prevailing south-westerly winds was definitely indicated, and this spell was to prove unusually persistent. Gales were reported somewhere in the British Isles on 22 days between January 8th and February 1st, and on several days affected considerable areas of the country. The first major gale of the winter swept the western and northern coasts on the 12th and 13th, and was severe at times off west

Scotland where Stornoway and Tiree, both in the Hebrides, experienced gusts of 87 m.p.h. and 77 m.p.h. respectively. The renewal of the gale on the following day was to prove more violent and destructive than its predecessor and developed into the most widespread gale experienced over the country as a whole for a considerable time.

The earliest signs of a new formation were detected on January 11th off the American coast north of Florida, but for two days this remained quiescent whilst drifting slowly east. The first definite indications of the new disturbance appeared on the chart for 1300, January 13th, in Lat. 38° N. Long. 37°W., the central pressure


SYNOPTIC CHART FOR 7 am
15th JANUARY 1938
LYRA
BERGENSFJORD
SCYTHIA
BERENGARIA
WARWICK CASTLE
LOW
HIGH
1000 mb
996
992
988
984
980
976
972
968
964
958 mb
1004
1008
1012
1016
1020
1024
55°
50°
45°
40°

being 1008 mb. At this stage the warm front of the new depression became associated with the retrograde cold front of the major low pressure system covering most of north-west Europe, and five hours later it was apparent that a large warm sector with air temperatures of 63° F. to 66° F. was operating to cause considerable developments which thereafter proceeded apace. The subsequent behaviour of the new system is shown on the figure on which successive positions of the centre and the central pressures are given. Six hours later strong winds were reported in the vicinity of the centre; the SS. *Bristol City* south-westward of the centre in Lat. 47·5° N. Long. 17° W. reported " Storm SW. 11 " and the *Holystone* nearly 200 miles further east had a "whole gale" SW. 10, and Beaufort force 9 was reported as far south as the Portuguese coast. The Master of the *War Bahadur* reported squalls of hurricane force and mountainous seas at midday, and by 1500 estimated the wind as a full hurricane Beaufort force 12 with gusts of 100 m.p.h., the sea precipitous and dangerous about 60 ft. high. A wave which caused major damage he estimated at 70 to 80 ft., and goes on to add that the storm was still at its height at 1800, with visibility nil and hundreds of tons of water breaking over the ship.

The fall in pressure had set in over south-west Britain by 0700 on the 14th and by 1300 winds had freshened to force 7 from between SE. and S. with rain on the south-western coasts of the British Isles and round Brittany. Gales had spread across Ireland, South Wales and south-west England by 1800, with strong winds in the Channel and on the east coast, and rain throughout the country. The autographic records from stations in the west are remarkably similar, and the following extracts from a note by Mr. G. W. Hurst, Meteorological Officer at Pembroke Dock, after an examination of the records there and of the records of the anemometer at St. Ann's Head in the centre of the area experiencing the full violence of the gale, summarises the sequence of events on the western side of the country:—

"After a further 12 hours (from 1800 G.M.T., 14th) there was little warm air left on the surface. . . . The warm front reached Pembroke soon after 1430 when the wind veered slowly from SE. to SSW., the wind being about 40 m.p.h. at this time. There was a fairly sharp veer at 1920 on the 14th from S. by W. to SW. at the passage of the cold front which was remarkable in that no squall was recorded and that the wind immediately dropped from about 50 m.p.h. to 30 m.p.h. (This phenomenon of a decrease in velocity at the cold front was even more marked at the Scilly Isles, and was recorded at Holyhead, Sealand and Aldergrove. F.H.D.) The wind then slowly increased to reach gale force again by 2200. The thermograph bears out the times reasonably well—the temperature rose sharply 1° F. at 1530 and fell 1° F. between 2030 and 2045. . .

Gales were particularly fierce in the Irish Sea area, where the wind maintained at over 50 m.p.h. for many hours ; very high gusts were recorded. The following figures from the anemograph at St. Ann's Head during the period of the gale are striking. By 1400 on the 14th the wind reached an average of 40 m.p.h. and except for a spell between 1930 and 2200 on that day, it remained above 40 m.p.h. until about 1800 on the following day. From 0300 to 0700 on the 15th the wind averaged nearly 70 m.p.h., and a gust of 101 m.p.h. was recorded. The wind gusted to over 90 m.p.h. on many occasions".

The depression had attained its lowest pressure, about 958 mb., just off West Ireland at 0100, January 15th ; winds had increased to gale force over most of the country and widespread gales extended at least 600 miles westwards across the Atlantic and southwards to the coast of Portugal. Winds were everywhere increasing and had already reached 71 m.p.h. in a gust at Scilly, whilst by 0700 gust speeds (additional to that at Pembroke) of 78 m.p.h. had been recorded at The Lizard, 75 m.p.h. at the Scilly Isles and 68 m.p.h. at Holyhead.

On the eastern side of the country the winds veered from S. and SW. to W during the forenoon and immediately increased to their maximum intensity. Meanwhile the gale continued unabated in the west, where some places had their maximum gusts round the middle of the day before the gale at long last began to subside. The final phase of the gale occurred in Scotland and north-east England toward evening and developed well behind the centre of the disturbance.

The prolonged duration of the gale at Pembroke has already been referred to : at Mount Batten (Plymouth) the gale was continuous for 22 hours, at the Scilly Isles there was a temporary break after three hours followed by a continuous blow for 15 hours. At the Lizard it maintained at gale force with interruptions for a total period of 12 hours, at Holyhead and Cork for 11 hours, but for five hours at Spurn Point, three hours at Tynemouth and only two hours at Eskdalemuir.

Some exceptionally rapid falls of pressure occurred with the advance of the depression, the most noteworthy being a fall of 11·8 mb. at Valentia in the three hours preceding 1300 on the 14th, one of 15·0 mb. at Malin Head between 1500 and 1800, and a negative tendency of 10·0 mb. reported from Blacksod Point at 0100. The total falls in pressure were large and varied across the country from 47 mb. at Scilly and 44 mb. at Blacksod Point to 35 mb. at Aberdeen and to 27 mb. at Stornoway and Croydon ; these are considerably larger than those noted during the gale of January 12th, 1930. Pressure rose at the rate of from 9 to 12 mb. in 3 hours in the rear of the disturbance near the track of the centre, but tendencies were not unusually pronounced elsewhere.

Rainfall on the whole was not unduly heavy, averaging roughly about 0·5 in. along the track of the centre of the disturbance ; 0·85 in. was measured at Colwyn Bay, 0·64 in. at Morecambe and 0·61 in. at Harrogate. The limited reports to hand indicate considerably heavier falls exceeding one inch in the hill districts, the largest fall so far reported being 3·35 in. in Westmorland.

It is of interest to note that on this occasion the completely developed system travelled some 700 miles across the Atlantic, whereas in the general case, severe and widespread gales in this country are associated with active secondary disturbances which develop relatively close in to the British coasts and then move quickly across the country.* The system had just begun to occlude at 0700 on the 14th, and six hours later when it was occluded to a point within 150 miles due west of Valentia, the warm front was located approaching Valentia extending east-south-east to The Lizard and across to central France. The cold front stretched almost due south towards Corunna and then recurved south-westwards. The cold front had reached the line Aberdeen–Croydon–Lisbon by 0100 on the 15th, and an important development occurred at about this time. The change of direction in the track of the centre will be noted on the chart, whilst the wind S.7 at Blacksod Point, with a tendency of —10·0 mb. is significant. Unfortunately there are no autographic records available to assist in the solution ; the original bent back occlusion already noted on the Atlantic must have been well in advance of the vital position. It is certain that a small " bulge," if not an actual small centre, developed over or near NW. Ireland and whilst this moved north, the main centre came through on an easterly track across north Ireland and north England. With the highest pressure located far to the southward and the steepest pressure gradients to the south and south-west of the centre, conditions were in favour of the change to an easterly movement of the centre after its occlusion. At least one half of the total fall in pressure occurred subsequent to the passage of the cold front and the gale reached its greatest intensity in the Irish Sea area rather later than 0400 with definite frontal indications. This front is shown on the chart for 0700 on the 15th, extending from just north of Ireland to about Ross-on-Wye. C. K. M. Douglas considers that this front resulted from the change in motion of the system following occlusion of the centre and probably from the convergence into the " isallobaric low " engendered by the development. It was with the passage of this front that the winds attained their maximum speeds also in the eastern counties. Once over the North Sea, the centre turned sharply northwards ; it appears to have filled up fairly quickly and was lost as a separate entity.

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* *London, Met. Mag.* 70, 1935, p. 229.

Shipping, in the main Atlantic routes westward to mid-Atlantic, was caught in the direct path of the storm whose fury remained unabated until it had swept across the whole of the British Isles. Photographs in the daily press, of the extensive damage to the superstructure of the Government tanker *War Bahadur* which arrived at Plymouth on the evening of the 17th, after having jettisoned some of its cargo, eloquently depicted the violence of the storm in mid-ocean, where the freighter *Cragpool* was also in difficulties for a time. Further east, the maximum force of the gale was experienced in the Irish Sea area where two steamers were reported to have foundered with a feared loss of 22 lives, whilst at least three other men lost their lives following accidents to two more coasting steamers, and others were injured. Lesser mishaps at sea included a collision between two British ships in the Thames, whilst the cross-Channel steamer *Isle of Thanet* was in collision with the quayside at Folkestone. Around the coasts of Wales, Lancashire and Cumberland the gale was coincident with some of the highest spring tides. At Aberystwyth the high seas completely destroyed a portion of the promenade and caused other extensive damage and flooding to some of the hotels and other buildings near the front. The sea defences were damaged with consequent flooding at various other points along these coasts, and in west Cumberland the railway embankment was washed away after the sea wall had been demolished. Inland, with the exception of one fatal accident in Westmorland, the damage was confined to fallen trees and hoardings. A phenomenon noted with previous heavy gales* was reported from Ross-on-Wye where a " salty " deposit was observed on the glass sphere of the sunshine recorder after the gale, evidence of the amount of salt spray driven well inland by the wind. Extreme velocities registered during the gale in the west were a gust of 101 m.p.h. at St. Ann's Head, 86 m.p.h. at Holyhead, and 82 m.p.h. at the Scilly Isles. A gust speed of 100 m.p.h. was previously recorded at St. Ann's Head in January, 1936, and one of 107 m.p.h. at Holyhead in February, 1937. Wind velocities of 100 m.p.h. or more have now been recorded 12 times in various parts of the British Isles.†

In the south 70 m.p.h. was registered at Calshot, 68 m.p.h. at South Farnborough and 62 m.p.h. at Croydon and Lympne during the forenoon. The maximum gusts recorded in the north-east of the British Isles included 70 m.p.h. in gusts at Eskdalemuir and Aberdeen, and 69 m.p.h. at Catterick.

Events have proved that the gale described above was to be but one of a series of recurrent, widespread, heavy gales in many parts of the United Kingdom. January merged into February with gales still whining and howling from Lands End to John o' Groats.

The Aurora of January 25th–26th, 1938

On the evening of January 25th a magnificent display of aurora was observed over the British Isles, continuing until the early hours of the 26th. According to newspaper reports it was also seen over most of Europe and in the Mediterranean, and it was probably still more widespread. Information from an incoming Union Castle liner states that it was observed as far south as Madeira.

The aurora was accompanied by a great magnetic storm. This, at Abinger, was more intense than any recorded by the Greenwich observers since that of September 25th, 1909. The disturbance began just before noon on January 25th, but up to 1600 G.M.T. did not exhibit unusual intensity. By 1800, however, it was evident that a great storm was beginning and this continued until about 0200 on the 26th. Solar activity is now at or near the maximum of the present cycle, but at the time of the magnetic storm the sun's visible hemisphere showed no large spot. A great sunspot passed the sun's central meridian at about 1000 on January 18th, this being one of the six largest sunspots photographed at Greenwich since 1875. By January 25th this had just passed out of sight at the western limb, where a great prominence display was observed over it.

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* *London, Met. Mag.*, 62, 1927, p. 277 and 63, 1928, p. 131.

† *London, Quart. J. R. met. Soc.*, 62, 1936, p. 195.

Occasional auroral manifestation is not uncommon in the south of England but great displays are rare. It has been stated that the recent aurora was the finest so seen in the last 50 years, but it is difficult to make any such statement with confidence, since memories are proverbially short and for real comparison the same person should have viewed the aurora on all occasions. The last notable aurora in the south of England occurred on December 25th, 1918. I saw this at Bournemouth and the display was in every way inferior to the recent one. From 1881 to 1917 there were, I think, only six notable displays, two of which were seen in 1882, and one in 1917. It is sometimes stated that aurora is only seen in the south of England in the years of high or maximum solar activity, but this is not the case. Dr. C. L. Prince's book, "The Topography and Climate of Crowborough Hill, Sussex," contains monthly notes on phenomena observed during 1871 to 1897. Aurora was seen on 18 nights in the 27 years. Only 10 of these occasions fell within 5-year periods centred on the dates of maximum solar activity, while two were at times of minimum activity.

Many observations of the recent aurora have appeared in newspapers, but the description given here is confined to accounts received by the Meteorological Office. The aurora began in south-east England at about 1815. Mr. A. E. Moon saw it at this time at Hastings. Leaving Wadhurst Station, Sussex, at 1830, I saw a bright auroral arch which I was told was not visible at 1800. My last observation was at 0100 on the 26th and aurora was not seen at Greenwich Observatory after 0115. The duration was thus about seven hours. Father J. Ellsworth-Norton, S.J. saw it earlier, at 1745, at Chipping Norton, Oxon. Mr. Morgans first saw aurora at Catterick at 1815, and it was still in progress at 0200. Mr. S. E. Ashmore, of St. Asaph, cycling for some hours in the Wrexham district, saw it at 1820 and it was still continuing at 0145. The duration further north was therefore somewhat longer.

The aurora presented many interesting features, apart from its duration. Save for one relatively stable period, change was continuous, making accurate sketching almost impossible. With the exception of the great fully-developed curtains seen in arctic regions, every variety of auroral manifestation was seen in south-east England, and the colour effects were magnificent. A striking feature was the extent of light south of the zenith, and even on the southern horizon. The quickly-changing aurora of varied types is perhaps characteristic of those produced in relatively low latitudes by great magnetic storms. Two auroræ which I saw in September, 1932, in the western North Atlantic, when solar activity was low, were of different character. Although somewhat brighter, they showed less variety, with perfectly regular arches at times, did not reach the zenith and had no red coloration.

The rapid changes make identification of features seen by different observers difficult. The two red rays at 2205 sketched by Mr. D. L. Champion, of Goff's Oak, Herts (Fig. 1) were, however, drawn in the same position at 2200 by Mr. L. Cundall, Morden, Surrey.

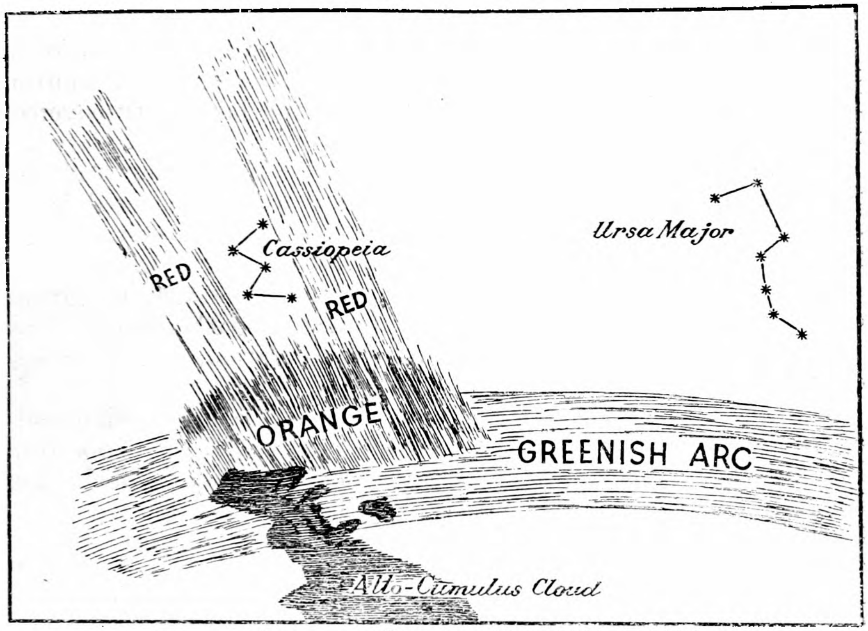


FIG. 1.—AURORA OF JANUARY 25TH, 1938 AT 2205

Mr. Champion writes: "The beautiful rays, of carmine tint, rising from the greenish arc of light at 22h. 05m., G.M.T. practically reached the zenith, the two rays enclosing the constellation of Cassiopeia, as shown diagrammatically . . . The greenish light of the arc was so intense as to completely mask stars of all but the 1st magnitude." He also states that aurora has been seen in his district only twice before in the past 30 years.

The display at Wadhurst can be broadly divided into eight periods, a brief summary of which is given below:—

(i) 1830–1855. Bright irregular arches and few rays. Arches often very complex. No red coloration.

(ii) 1855–2015. Development of rose-pink rays, at first at the west and east ends of the arches. Rapid arch changes, with intense luminosity of small areas at times. At 1915 little vertical brushes appeared along the upper edge of the lower arch, flashing up almost instantaneously in succession from east to west. Great bands of red rays formed and changed, with much variety of colour, rose-pink, crimson, orange, purplish-red, etc. From 1915 to 1945, the sky high in north and north-east was suffused with a deep blood-red colour, tending to violet, of low luminosity. This period culminated in the great " flame " aurora, from 1950 to 2005 ; the whole northern sky, from west to east and up to near the zenith was covered with bright flame-coloured light, obliterating the arches and giving, as Mr. Moon writes, " the impression of a great fire reflected on a cloud sheet." Definite red rays were conspicuous on this background. The red light ended about due east in a nearly vertical curtain, hard-edged against the starlit sky.

(iii) 2015–2100. Absence of red colour, save for occasional rays and bands. Arches prominent and great extension of whitish light to the zenith and beyond. At 2035 the luminosity covered two-thirds of the sky.

(iv) 2100–2142. Irregular patches only. No arches and no red coloration. White and greenish-white patches covered large areas, with a pale blue one at one time low in north-west. Large luminous areas in the southern sky, notably through Orion.

(v) 2142–2215. Arches reformed, quickly followed by great development of red rays. Patches continued in southern sky.

(vi) 2230–2330. At the intervals of observation, bright arches only.

(vii) 2353–0030. Great resumption of activity and redevelopment of red rays, providing the finest spectacle next to that of period (ii). For five minutes from midnight there was very marked flickering in north-north-west about the apex of the arch. Ill-defined patches flickered in and out, and sections of the lower arch in the region of the apex flickered brightly into view and disappeared several times. At 0015 rays, greenish below and red higher up, radiated from points along the entire length of a bright greenish-white arch.

(viii) 0100. Three white rays in north-north-west and remnants of an arch.

The stars were very bright before the aurora began. At their brightest the arches threw a definite shadow of one hand on the palm of the other and illuminated the garden with a faint light. The arches were double for the greater part of the time ; Dr. Prince states that the second arch is very rarely seen in the south of England. Both arches were always irregular, in greater or less degree. Fig. 2 shows their structure at 2030. I have called the lowest part the " arch curtain " ; it was not separated from the second arch by a dark space and it was of a very uniform appearance, with a tendency to " fold " at its lower, clear-cut edge. The altitude of the arches varied much, the maximum for the main arch being about 45°. Sudden brightening of the whole arch occurred at times, with a change to a generally ill-defined appearance, and colour change from greenish-white to greenish-yellow. Rayed arches were seen for short periods, and also by Mr. Morgans, the arch being built up of short separated radial rays. There were intermediate stages when the dark segment below the arch projected into it in innumerable sharply-pointed spikes. In spite of the rapid changes there were no rays of which the movement along the arch could be followed with the eye; this was a prominent feature of the aurora of 1918. The east and west ends of the arches were the most active regions during much of the time. It will be noted that aurora south of the zenith was confined to the period 2015–2215.

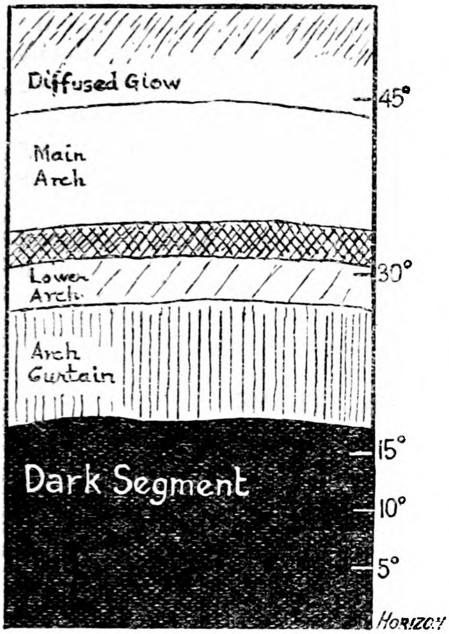


FIG. 2.—STRUCTURE (DIAGRAMMATIC) OF THE ARCH AT 2030, WADHURST.

I saw no complete corona, though the ends of some of the great red rays formed the quadrant of a circle near the zenith at 1950. Miss C. M. Botley, observing at Hastings the finest part of the display, between 1945 and 1952, saw a corona momentarily formed. Mr. Morgans saw a corona from 1947 to 1955, in which rays diverged from near the Pleiades to the horizon in all directions except extreme east. The main colour was green, with red towards the base of the cone of rays. The corona reformed at 2035 and again at 0200. Mr. Ashmore saw a bright red corona at 2040, the radiant point being 10° due south of the zenith. He states that every form of aurora was seen, the curtain and the arch being at first predominant. At one time the light reached to 30° south of the zenith. Mr. Cundall saw a purple patch at 2130, which moved into the western sky. The most striking observation of unusual colour was the great indigo patch of feeble luminosity seen due south about 2100 by Dr. C. E. P. Brooks at Ferring, Sussex. This extended from the horizon to about 45° and was separated by greenish luminosity from a great indigo band extending from near the west point up to the zenith. Closely north of this in azimuth was a vertical rose-coloured ray. Rippling and pulsating appearances are referred to by Mr. Parsons, of Ross-on-Wye, Mr. Morgans and Mr. Moon. Mr. Parsons thinks that the aurora was inferior in luminosity to that seen at Ross on October 1st, 1919. He appears to have seen little red colour and the light never quite reached the zenith. The aurora was well seen by Mr. J. Phillips at Dalwhinnie, Inverness, and by Mr. R. K. Pilsbury at

Lee-on-Solent, who describes the red glow as bright enough to be visible in a brightly-lit main street.

At the time of the "flame" aurora in south-east England, Mr. Morgans in Yorkshire was observing the corona, with mainly green rays. From 2000 to 2025, Miss M. C. L. Bowden, at Dovercourt, Essex, saw two separate red belts pierced at intervals by pale yellow rays. During this time the flame coloration at Wadhurst was rapidly dying out and by 2015 the greenish arch was the only prominent feature. These observations indicate a totally different appearance of the aurora at the same time in places rather widely separated.

Solar activity should continue to be high for some time and further auroral displays may occur during the next year or two, but it is unlikely that such a fine aurora will be again seen, at any rate in the south of England. The chances of another display after an interval of one solar rotation (about 27 days) from January 25th are not great.

E. W. Barlow.

OFFICIAL PUBLICATIONS

The following publications have recently been issued:—

Professional Notes

No. 78. Upper Winds at Kingston, Jamaica. By S. Proud, B.A. (M.O 336r).

In this note 11 years' pilot balloon observations are examined and reveal a well-defined wind structure above Jamaica. The trade wind blows mainly from E. or SE. at Kingston and extends upwards through several kilometres before being superseded by the counter-trade, which is an extension southwards above the trade winds of the westerlies of temperate latitudes. The tables and wind roses incorporated in the note demonstrate that the surface of separation between the trade and counter-trade slopes upwards towards the south and experiences a north and south seasonal oscillation which shows a time lag of approximately two months behind the sun; wide diurnal variations in the height of the base of the counter-trade also occur. Several high ascents to 15 Km. or more indicate the existence of an easterly current above the counter-trade. On rare occasions the trade wind was absent at all heights above Kingston, and it is shown that in such cases either the main polar front was in the neighbourhood of Jamaica or a tropical storm was forming in the surrounding seas.

Professional Notes

No. 79. Upper winds measured at M/Y Imperia, Mirabella Bay, Crete. By J. Durward, M.A. (M.O. 336s).

Observations of upper winds at Crete are of great importance for aircraft operating between Athens and Alexandria. A pilot balloon station was opened in 1934 but it was unfortunately necessary to make the observations at the seaplane base at Mirabella Bay where it was felt that the results would be vitiated by vertical and eddy currents.

In Professional Notes No. 79 the author, in addition to giving summaries of the results in the form of tables as recommended by the International Commission for Air Navigation and in direction-constancy diagrams, discusses the validity of the observations. The method adopted is to compare the measured wind with the wind computed from the pressure gradient on the current synoptic chart. This was done on 204 occasions and on 52 (i.e. about 1 day in 4) there was a marked discrepancy between the two measurements. These 52 occasions are discussed in some detail and the conclusion reached that the majority of the discrepancies may be explained by a quasi-permanent eddy in the lee of Mount Oxia and Mount Pyrgos. The existence of this eddy is often revealed by the white squalls which occur at its forward edge and by the very difficult landing conditions frequently experienced by flying boat pilots.

It is found that in the majority of these doubtful cases, the gradient wind and the wind measured at 3,000-4,000 ft. are in close agreement.

Discussions at the Meteorological Office

The subjects for discussion for the next two meetings are :—

February 28th, 1938. Mr. C. K. M. Douglas, B.A., will describe a series of cloud films recently produced in Germany, and annotated by Dr. Mügge. The meeting will be held in the Science Museum, South Kensington, and will commence at 4.30 p.m.

March 14th, 1938. *Sudden disturbances of the ionosphere.* By J. H. Dellinger. Washington, J. Res. Nat. Bur. Stand., 19, 1937, pp. 111–141. *Opener.*—Dr. D. N. Harrison.

Royal Meteorological Society

The Annual General Meeting of the Royal Meteorological Society was held on Wednesday, January 19th, in the Society's house, 49, Cromwell Road, South Kensington. Dr. F. J. W. Whipple, F.Inst.P., President, was in the Chair.

The Report of the Council for 1937 was read and adopted and the Council for 1938 duly elected, Dr. B. A. Keen, F.R.S., being elected President.

A By-law authorising the titles and abbreviated titles to be used to indicate the various classes of membership of the Society was adopted.

The Symons Gold Medal for 1938 was presented to Dr. Gordon Miller Bourne Dobson, F.R.S., Reader in Meteorology in the

University of Oxford. (This medal is awarded biennially for distinguished work in meteorological science.)

Dr. F. J. W. Whipple delivered an address on " Modern views on atmospheric electricity." The central theme of the address was the circulation of electricity through the atmosphere. The following is an abstract:—

" Clouds from which precipitation is falling act as generators of electricity. Recent work by Sir George Simpson and Mr. Scrase supports the view that the separation of positive and negative electricity is mainly due to the impact of snow particles in the upper parts of the clouds. The snow particles bring negative electricity downwards and a current of positive electricity flows upwards to the ' Heaviside layer ' to come down again in distant places where fine weather happens to prevail."

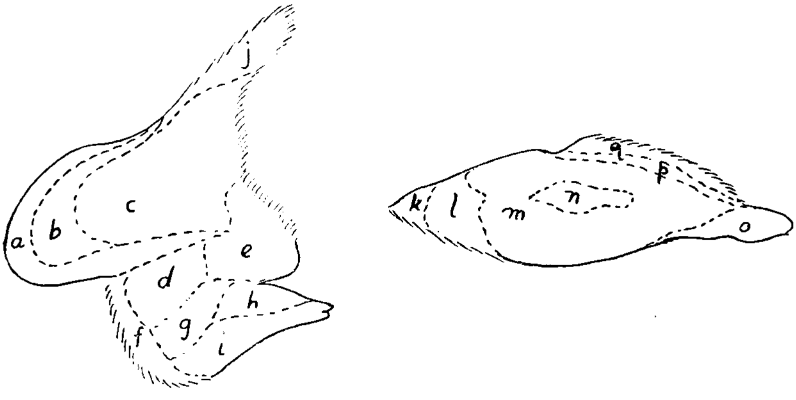
The address was illustrated by lantern slides, many of which were reproductions of autographic records obtained at Kew Observatory.

Correspondence

To the Editor, *Meteorological Magazine*

" Mother of Pearl Clouds "—January 28th–29th, 1938

Some particularly beautiful " Mother of Pearl " clouds were seen here during this afternoon. The clouds were first noticed at 1230 G.M.T. when a small lenticular cloud could be seen between



(*a*) Orange and yellow.
(*b*) Reddish orange.
(*c*) Blue green shading to green.
(*d*) Electric blue.
(*e*) Green and blue.
(*f*) Magenta.
(*g*) Electric blue and silver.
(*h*) Orange.
(*i*) Silver.
(*j*) Silver grey with violet edge.
(*k*) Orange.
(*l*) Red.
(*m*) Light green.
(*n*) Blue and green.
(*o*) Electric blue.
(*p*) Orange.
(*q*) Red with yellow edges.

Mother of Pearl Clouds
Aberdeen—January 28th, 1938

large patches of cirrus nothus. This lenticular cloud was red in colour with green edges and at first was taken to be an ordinary form of iridescent cloud. By 1300 it was seen that there were patches of very high cloud showing brilliant colour effects in the south-west section of the sky. These were obscured at times by the passage of lower cloud. At 1400, however, the sky had cleared considerably and the clouds seen in the accompanying sketch were observed. In addition to these two clouds there were present other small faint patches of "Mother of Pearl" clouds. The clouds appeared to be moving extremely slowly from a north-westerly direction. Colour effects were still noticeable as late as 1700 after the sun had set.

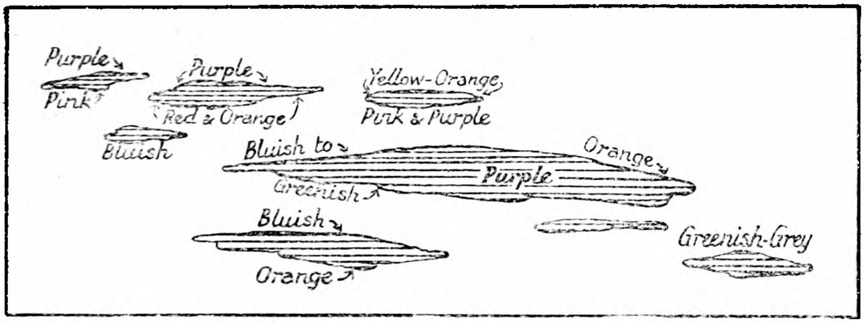
Surface conditions between 1300–1430 G.M.T.

Wind.—Force 5–6, variable between WSW. and WNW. Unusually good visibility to N., NW. and NE. from 1400–1430.

W. F. Watson.

The Observatory, King's College, Aberdeen, January 28th, 1938.

A very interesting example of luminous clouds occurred here between 7h. 45m. and 8h. 15m. on January 29th, in the south-east part of the sky at an elevation of 25° to 30° above the horizon. The attached sketch indicates the different colourings observed.



Luminous Clouds seen at Ross-on-Wye

The clouds were small lenticular cirrocumulus and had a similar glistening appearance to those illustrated in Sir Napier Shaw's book "Forecasting weather" (a photograph taken in Scandinavia, I think). They were of great beauty and striking colours—as one sees on a mother-of-pearl ornament, or when petrol has been spilled. The blue-green was very vivid.

F. G. Parsons.

The Observatory, Ross on Wye, January 30th, 1938.

NOTES AND QUERIES

Changes in Daily Weather Report on January 1st, 1938

Since 1930 the British Section of the *Daily Weather Report* has contained a "morning" weather chart for the greater part of the Northern Hemisphere. The observations presented on this chart are not synchronous but this year a change has been made which gives approximately synchronous observations over a larger area than formerly.

Till the end of December, 1937, the chart could be divided into the following three sectors as regards hour of observation :—

Sector.	*Hour of Observation.*
U.S.S.R. (approx. 170° E. to 30° E.)	7h. local time.
30° E. to 40° W.	6h. or 7h. G.M.T. (Azores 8h.)
40° W. to 170° W.	0h. or 1h. G.M.T.

From January 1st, 1938, these have been reduced to the two sectors :—

Sector.	*Hour of Observation.*
U.S.S.R. (approx. 170° E. to 30° E.)	1h. local time.
30° E. to 170° W.	0h. or 1h. G.M.T.

The improvement in the charts effected by this change is most marked over mid-Atlantic. Previously a difference of six hours had existed between observations from ships on opposite sides of the line of longitude 40° W. Strictly the isobars should have shown the discontinuity when pressure changes in six hours were appreciable at points along this line; for various reasons continuous isobars were invariably drawn. In consequence pressure systems in mid-Atlantic with closed isobars and having an appreciable west-east component of motion tended to become distorted, the isobars circumscribing them being unduly elongated in the west-east direction.

The gain in one respect has meant a sacrifice in another. The network of land stations in Europe and Africa making observations at 1h. is not so close as that of stations observing at 7h. This is particularly notable in Scandinavia, the Balkans and North Africa. In the case of Iceland entries of weather, temperature and wind do not now appear on the chart, but pressure values at 1h. G.M.T. are available and are used in drawing the isobars.

A change was also made in the Upper Air Section of the *Daily Weather Report*. From January 1st, 1938, upper winds obtained from pilot balloon ascents and nephoscope observations have been reported in kilometres per hour instead of miles per hour; and heights, in the case of balloon ascents, in metres instead of feet. To obtain the approximate speed of the wind in kilometres per hour from nephoscope observations the heights assumed for medium and high cloud are 5 and 8 kilometres respectively: these are approximately the equivalents of the heights 3 and 5 miles formerly used.

Upper winds obtained from pilot balloon ascents continue to be reported for certain fixed levels but, in addition, the levels at which changes from one régime of wind to another occur, are set out at the bottom of the columns so far as space will permit.

REVIEWS

Sunspots and their effects. By H. T. Stetson. Size 8 in. × $5\frac{1}{2}$ in., pp. xv + 201. *Illus.* New York and London. McGraw-Hill Book Co. Inc. 8*s.* 6*d.* net.

At the moment of writing this review, sunspots are very much "in the air," the appearance of a large spot, visible to the naked eye, on January 19th having been followed on January 25th by a most spectacular display of aurora. The close relation between sunspots and auroræ has long been known and, like the equally intimate connexion between sunspots and magnetic storms, has its seat high up in the ionosphere ; changes in the ionosphere also cause marked variability in the reception of radio signals, which show a close though complicated relation to the sunspot cycle. All these effects are very clearly described and explained by Dr. Stetson in the chapters on "Sunspots and radio," and "Of Sunspots, the earth's magnetism, and carrier pigeons ".

Sunspots do not stop in the heavens however ; there is much support for the idea that they descend to earth and play a large part in the affairs of men. The author discusses the possibilities in a vigorous way, but he is always careful to warn us when basis of facts is slender. He deals first with " sunspots and human behaviour," and describes a number of researches which tend to show that the quality of the sun's radiation at sunspot maximum differs from that at sunspot minimum in such a way as to cause a physiological or psychological cycle in human beings. Bearing in mind the therapeutic effect of ultra-violet radiation and its great variability on the sunspot cycle, he thinks that this is probably the important factor though an electrical connexion may also be possible. " Sunspots and growing things " is mainly devoted to the investigations of Prof. Douglass into the cycles of tree-rings, which are shown by data, extending over thousands of years, to be closely related to sunspot cycles of 11 and 23 years. Relations to vintages and to animal populations are less convincing because the records are short. This criticism applies with still greater force to " sunspots and business "—business activity, manufactures in general, production of automobiles and building contracts, all supply material for striking diagrams, but in most cases these cover only one sunspot cycle and they are hardly independent witnesses. The author thinks that they are expressions of mass psychology and so share in the effects of sunspots on human behaviour, but much more evidence is required. The relations between sunspots and weather are equally uncertain, and the author limits himself to a broad general description of the principles involved, mainly illustrated by the work of Clayton and Abbot.

The astronomical parts of the book are distinctly good. Sunlight is measured from ultra-violet to infra-red without a trace of tears. To give the cash value of the light and heat supplied by the sun in dollars seems rather materialistic ; when figures reach quadrillions they are so impressive as to be unintelligible. On the other hand, the account of the source of the sun's energy, and especially the chapter on the nature of sunspots, their growth, migration and decline, are excellent examples of clear non-technical exposition, and the book ends with an interesting discussion of the causes of these disturbances. The author is an astronomer who is at present working on relations between cosmic and terrestrial phenomena; he is also a great admirer of Dr. Abbot, to whom he dedicates a book which he was well qualified to write.

Synoptic and Aeronautical Meteorology. By Horace Robert Byers, Sc.D. Size 9¼ in. × 6 in., pp. ix + 279. *Illus.* New York and London, McGraw-Hill Publishing Co. Ltd., 1937. 21*s.* net.

Dr. Byers is in charge of air mass analysis in the U.S. Weather Bureau, and has produced a very readable book, which is not excessively technical but is nevertheless sufficiently advanced to give an adequate idea of modern meteorology. The book is intended for aeroplane pilots and others who have previously had some instruction in elementary meteorology. The treatment is non-mathematical except for the quotation of some fundamental formulae, and includes such subjects as tephigrams, Rossby diagrams, and atmospheric turbulence. Though the book deals primarily with the practical needs of aviation, it rightly starts with a chapter on radiation, since this is the foundation of all atmospheric processes. Modern synoptic methods, in particular air mass analysis and fronts, are the main theme of the book. The general treatment of the subject is excellent, being based on adequate practical experience. The following passage (p. 139) is worth quoting. "No amount of reading or study can take the place of actual work with the maps. It is no more possible to become a synoptic meteorologist through reading than it is to become an analytical chemist or a practising physician."

The discussion of air masses is naturally based mainly on conditions in America. The colder parts of the Atlantic are mentioned as a "source region" for polar maritime air. Over the British Isles air masses often arrive from that region, but most of these, at least from mid-September to May, have come recently from a much colder snow covered area, which constitutes the real "source region". The term "source region" has a relative significance, as even over the snow covered areas conditions are frequently disturbed, and in such cases the air mass is unlikely to be in radiative equilibrium, or to have a negligibly small horizontal gradient of temperature aloft. The chapter headed "Weather Forecasting" is devoted entirely to Dr. Petterssen's rules, but the greater part of the book is relevant to forecast problems. Dr. Petterssen's recent work on frontogenesis also receives attention. Figs. 36 and 37 illustrate two types of frontogenesis off the south-east coast of America, due respectively to air movements and to locally produced temperature difference.

The two sets of charts do not present a striking contrast, and give the impression that the two factors are both operating in different degrees.

As one would expect in a book written mainly for air pilots, such vital factors as fogs, ice formation on aircraft, and warm front clouds are fully discussed. In a later edition there might with advantage be a fuller discussion of all kinds of cloud structure. The reviewer does not altogether agree with the remarks on turbulence and clouds on p. 58.

The more speculative questions do not enter greatly into the scope of the book. The treatment of cyclogenesis (pp. 86–87) is inadequate. It is said that a surface of discontinuity becomes steeper than its equilibrium position, that equilibrium is restored by the cold air pushing under the warm, and that this starts a cyclone. This has been said before, but has never been verified, and presents grave theoretical difficulty. If the angle of slope of the front decreases, and the difference of the pressure gradient on the two sides increases, as it generally does near the centre of a developing cyclone, the temperature difference must increase considerably, whether the sloping surface is in equilibrium or not. There is no evidence of this, and there is generally no way of producing it. A mere sharpening of the front at ground level is not enough. There would need to be an increase in the total temperature difference across the front in the free air, in order that the hypothesis should be applicable. The question of dynamical instability produced by excessive sheer at a steeply sloping front is different, and is more likely to be true.

Though difference of opinion on some points is inevitable, the book as a whole can be strongly recommended, especially from the practical point of view.

C. K. M. DOUGLAS.

OBITUARY

We regret to learn of the death on December 14th, 1937, of Prof. Dr. Walter E. Bernheimer, Assistant at the Wiener Universitäts-Sternwarte.

NEWS IN BRIEF

We learn that Prof. H. Amorin Ferreira has been appointed Director of the Observatorio Central Meteorologico, Lisbon.

The Weather of January, 1938

Pressure was below 995 mb. from the south of Greenland to Bear Island (Iceland 988 mb.). Pressure was above 1025 mb. over the Azores and above 1035 mb. in Siberia, giving steep gradients for westerly winds across the Atlantic and British Isles, and for winds from SSW. over Scandinavia and northern Russia. The Siberian anticyclone lay north-west of its normal position. Over southern and south-eastern Europe pressure was almost uniform, about 1017 mb. Another area below 1000 mb. extended from the Aleutian Is. to Kamschatka, but over most of North America pressure differed little from 1020 mb. The Faeroes and southern Sweden were more than 10 mb. below normal, while north-west Siberia had an excess of nearly 15 mb. Pressure was below normal over the whole of the British Isles, the greater part of Europe and southern Asia including India. The deviations were small over most of North America, but reached +4 mb. over Newfoundland, +5 mb. at Nome, Alaska and —6 mb. at Dawson.

The distribution of temperature was of great interest. The abnormally strong south-westerly winds carried warm air far into the Arctic and mean temperatures of 20° F. or more were reported from Spitsbergen and Novaya Zemlya. Bear Island was 10° F., the arctic coast of Siberia 15° F. and Novaya Zemlya 20° F. above normal. Even Jakutsk near the "cold pole" with a mean of —42° F. was 5° less cold than usual. The area of abnormal warmth included all Europe except the Mediterranean lands and the west coast of the British Isles, while parts of Sweden and Germany, the Soudan and a large area from the Black Sea to Turkestan were more than 5° F. above normal. On the other hand central Siberia, in the centre of the anticyclone, had temperatures 10° F. below normal. The greater part of northern and western North America was abnormally warm, the excess reaching 10° F. in western Canada.

Rainfall was generally above normal over Europe except for the Mediterranean coast, but in Siberia and most of North America it was deficient.

Temperature was below normal in the west and north of India but above over the Peninsula, Bengal and Indochina. The greater part of the area was rainless. No broadcast data were received for Australia and New Zealand.

A series of very deep depressions passed over the British Isles giving gales over most of the country during the month. Temperatures were generally high particularly during the latter half of the month, and at several places in the southern part of England the air temperature did not fall below 32° F. Sunshine was below normal except in the east of Scotland. At Aldergrove in Northern Ireland only 27 hrs. were recorded, a new low January record for this station. Rainfall was considerably above normal, south-west Scotland receiving more than 150 per cent. of the average. An anticyclone extended over Ireland and Scotland from the 1st to 5th and temperatures were low in England and Ireland on the 2nd and 3rd, and also in Scotland on the 3rd, Abbotsinch recording a minimum of 19° F. in the screen and 17° F. on the ground. Ireland had 5–6 hrs. of sunshine on the 2nd and 3rd, and southern Scotland on the 2nd and 4th. Snow fell in the Midlands and on the east coast on the 3rd.

Fog was reported locally on the 5th. Temperatures rose in England on the 7th and 8th as a depression approached from Iceland, and there was much sun generally on the 7th and on the east coast on the 8th, while rain spread from the west. Some fog occurred in Scotland and northern England. Heavy rain fell in Scotland and Northern Ireland on the 9th and some snow in south Scotland and the Midlands. A gale was reported from Kirkwall, and thunderstorms at Plymouth and the Channel Islands. On the 11th temperatures fell again and low minima were recorded in the north, Eskdalemuir reporting 18° F. in the screen. Snow fell locally and southern Scotland had fog and mist. In England temperatures rose generally until the 16th when a maximum of 57° F. was recorded at Sealand and 56° F. was reported from several stations. The deep depressions moving across the British Isles brought gales in Ireland and Scotland on the 12th–14th, and over the whole country on the 15th, see p. 4. Rain fell heavily on the 14th in England and Wales, 3·35 in. at New Dungeon Ghyll Hotel, Westmorland, and 3·08 in. at Watendlath Farm, Cumberland. On the 17th an interval of cold, sunny, quiet weather occurred as a ridge of high pressure passed eastwards across the country, the south coast experiencing over 6 hrs. sunshine. This was followed by rain in south Scotland, fog in the south and renewed westerly gales at Markree. A further sunny period occurred in south England on the 19th, but another deep depression brought squally winds in the west and further heavy rain on the 20th in the north-west, Borrowdale and New Dungeon Ghyll Hotel recording 2·09 in. and 2·08 in. respectively. Temperatures dropped in Scotland on the 21st but remained high in England ; fog was reported from the Midlands and south-east and became general on the 22nd when day temperatures rose throughout the country but sharp ground frosts occurred at night. A series of deep depressions centred over the British Isles until the end of the month maintained squally weather and gales were reported every day except the 26th, being particularly severe over the whole country on the 28th and 29th. Temperatures remained high in England and Ireland on the 23rd and 24th, Cardiff recording a maximum of 59° F. on the 23rd, and maxima of 57° F. being general on the 24th. Good sunshine records of over 7 hrs. were obtained in east and south England on the 24th. Thunderstorms occurred in Scotland on the 26th and temperature fell ; on the 27th Eskdalemuir reported a maximum of 35° F. Rain and hail fell generally in the north and north-west, but the south coast had 5–6 hrs. of sunshine. The 28th was cloudy, mild and sunless, and thunderstorms were reported from many parts both on the 28th and 29th and were accompanied by heavy hail showers. The east and south coasts again recorded sunshine on the 29th—Lympne 6·8 hrs. and Hastings 7·1 hrs. ; 6–7 hrs. was obtained on the east coast on the 30th, and a maximum record of 8·4 hrs. on the 31st at Dublin, but elsewhere there was little sun. The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ..	30	+ 3	Chester ..	51	− 2
Aberdeen ..	64	+17	Ross-on-Wye	45	−10
Dublin	56	− 1	Falmouth ..	49	−11
Birr Castle ..	36	−13	Gorleston ..	49	− 7
Valentia ..	46	+ 2	Kew.. ..	45	+ 1

Kew, Temperature, Mean, 43·5, Diff. from average + 2·2.

Miscellaneous notes on weather abroad culled from various sources. Severe cold was experienced in central and southern Europe at the beginning of the month, and heavy snowfalls were reported from Paris, Berlin, and many parts of Italy on the 4th. Ice formation on an aeroplane caused the death of 6 people in a crash on the same day. On the 5th the temperature over the whole of Germany was reported to be below freezing point, rivers were ice covered, 46° of frost was reported from east Hungary, and the lagoon and some canals were frozen in Venice. Many deaths resulted from the extreme cold in Italy and France. On the 6th gales were experienced in the North Sea and Black Sea : a thaw set in in Berlin, but while snow was lacking in Switzerland, heavy falls occurred in Austria, and Adriatic ports were icebound. In Bukowina and Sofia 50° of frost was reported, wolves appeared and many people were frozen to death. A north-west blizzard in the Sea of Marmora caused delay to shipping on the 8th. Heavy rains from the 10th–16th, and the melting of the snow during the thaw caused widespread floods in Belgium on the 13th–15th, Germany on the 15th and France on the 16th. The West Hinder lightship broke from her moorings during a violent storm on the 15th, and fog and storms were reported in the Bay of Biscay. Snow fell in Switzerland on the 21st and winter sports conditions improved. Fog was reported from Venice on the 20th and in the North Sea on the 24th. Storms swept the Channel and Atlantic coasts on the 29th and a severe gale caused much damage and loss of life in France. Heavy snow fell in the St. Gotthard region on the 30th and avalanches blocked the railway line for several days. Further avalanches in the Engadine and Piedmont on the 31st caused the death of 5 people. (*The Times*, January 3rd–February 1st.)

The total rainfall for the month was deficient in the Northern Territory and west Queensland, but generally above normal over the rest of Australia, being more than twice the normal on the north-east coast of New South Wales.—(*Cable*).

Glazed frost and heavy snow in the eastern United States on the 1st dislocated all traffic and resulted in the death of 55 people. Fog caused damage to shipping at Seattle on the 2nd. A gale sweeping across Oklahoma and Kansas on the 13th threatened the wheat crops. Low temperatures were recorded in New York on the 18th and storms extended along the Atlantic coast delaying shipping. Gales and high temperatures were reported from New York on the 24th, and an aeroplane pilot lost his way in the torrential rain. The pressure of the ice pack caused the collapse of the Niagara Falls bridge on the 27th, and flood damage estimated at £200,000 was caused above the bridge. Temperatures again became low in New York on the 29th. (*The Times*, January 3rd–February 1st.)

Gales were reported from the Atlantic on the 5th, 14th–19th, 24th–25th, 30th–31st, causing much damage and delay to shipping. Severe storms in the Arctic on the 27th–31st threatened the safety of the Russian North Polar scientists. (*The Times*, January 8th–February 2nd.)

Daily Readings at Kew Observatory, January, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain.	Sun.	REMARKS. (see vol. 69, 1934, p. 1).
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1027·8	NNW.4	37	44	75	—	0·1	r_0 10h., 23h.–24h.
2	1031·0	N.3	40	45	81	0·08	0·2	r_0 13h.–24h. [17h.
3	1033·3	NE.2	36	36	74	0·01	0·0	r_0 0h.–2h., s_0 14h.–
4	1024·6	NNW.3	33	43	90	trace	0·0	r_0 10h.–13h. and 17h.
5	1027·3	NW.2	36	41	87	trace	0·0	r_0 7h., 10h., 12h.
6	1020·4	W.3	38	42	77	0·03	0·0	r–r_0 22h.–24h.
7	998·0	SW.4	39	46	76	0·01	2·5	r_0 0h.–2h., 13h., 20h.
8	996·3	WSW.2	37	46	90	0·01	0·6	ir_0 15h.–19h.
9	980·1	WSW.4	43	44	68	0·07	2·1	r_0–r 1h.–6h.
10	977·1	NE.2	35	39	91	0·15	1·0	rs 12h., r_0 till 15h.
11	1001·0	S.3	32	46	91	0·08	0·1	rs 12h., r 13h.–14h.
12	1003·9	WSW.4	43	54	83	0·15	0·0	r 0h.–6h., 23h.–24h.
13	1008·9	SW.3	44	53	78	0·44	0·0	r_0 0h.–6h., r 14h.–18h.
14	1013·2	S.4	41	48	88	0·07	0·0	r–r_0 15h.–20h.
15	991·8	SW.6	47	50	65	0·12	0·2	r–r_0 0h.–7h.
16	1001·0	S.4	42	51	95	0·23	0·0	r–r_0 7h.–15h., r_0 19h.
17	1012·5	WNW.4	43	46	67	0·04	5·6	r–r_0 4h.–6h.
18	1013·2	S.4	34	45	77	trace	0·0	x early, d_0 21h.–24h.
19	1012·4	W.3	44	48	65	0·01	6·4	r_0 0h.–1h.
20	1023·1	SW.3	43	52	73	—	0·1	
21	1023·4	SW.3	47	50	91	trace	0·0	id_0 14h.–16h., Fx late.
22	1030·7	SSW.3	37	50	91	—	0·0	f 9h.
23	1034·0	SW.3	47	50	82	trace	2·0	w early.
24	1033·2	WSW.4	46	55	68	—	6·2	pr_0 late. [Aurora.
25	1018·9	SW.4	44	50	81	0·11	2·4	r–r_0 11h.–13h.,
26	1012·1	SW.5	37	47	71	0·15	3·1	r–r_0 16h.–18h.
27	1011·3	WNW.4	34	43	68	—	5·2	x early.
28	1001·6	SW.3	34	52	87	0·07	0·0	r–r_0 4h.–8h. [q 0h.–17h.
29	998·1	W.7	44	46	47	0·09	5·5	tl 3h., rs 12h.,
30	1007·3	WNW.4	39	46	64	0·20	1·3	r–r_0 0h.–3h., 4h.–6h.
31	1006·1	SSW.3	39	51	88	0·09	0·0	ir_0 till 21h., r 23h.
*	1012·1	—	40	47	78	2·23	1·4	* Means or Totals.

General Rainfall for January, 1938

England and Wales	147	per cent of the average 1881–1915.
Scotland	162	
Ireland	144	
British Isles ...	150	

Rainfall : January, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
Lond	Camden Square	2·78	149	*Leics*	Thornton Reservoir	3·27	165
Sur	Reigate, Wray Pk. Rd.	3·61	150	,,	Belvoir Castle	2·39	135
Kent	Tenterden, Ashenden	3·74	174	*Rut*	Ridlington	2·68	145
,,	Folkestone, Boro. San.	3·96	...	*Lincs*	Boston, Skirbeck	2·64	163
,,	Margate, Cliftonville	2·66	160	,,	Cranwell Aerodrome	2·12	123
,,	Eden'bdg., Falconhurst	3·84	157	,,	Skegness, Marine Gdns.	2·06	119
Sus	Compton, Compton Ho.	4·93	155	,,	Louth, Westgate	1·98	91
,,	Patching Farm	4·11	158	,,	Brigg, Wrawby St.	1·83	...
,,	Eastbourne, Wil. Sq.	4·67	178	*Notts*	Mansfield, Carr Bank	2·61	121
Hants	Ventnor, Roy.Nat.Hos.	3·80	148	*Derby*	Derby, The Arboretum	3·05	146
,,	Southampton,East Park	3·75	140	,,	Buxton, Terrace Slopes	7·13	160
,,	Ovington Rectory	3·86	143	*Ches*	Bidston Obsy	2·70	127
,,	Sherborne St. John	3·04	131	*Lancs*	Manchester, Whit. Pk.	3·83	153
Herts	Royston, Therfield Rec.	2·62	151	,,	Stonyhurst College	6·25	146
Bucks	Slough, Upton	2·46	132	,,	Southport, Bedford Pk.	3·45	135
Oxf	Oxford, Radcliffe	2·65	146	,,	Ulverston, Poaka Beck	5·19	120
N'hant	Wellingboro, Swanspool	2·80	151	,,	Lancaster, Greg Obsy.	5·42	155
,,	Oundle	2·03	...	,,	Blackpool	3·77	138
Beds	Woburn, Exptl. Farm	2·49	146	*Yorks*	Wath-upon-Dearne	2·10	109
Cam	Cambridge, Bot. Gdns.	2·59	173	,,	Wakefield,Clarence Pk.	2·42	126
,,	March	2·48	155	,,	Oughtershaw Hall	11·69	...
Essex	Chelmsford,County Gdns	2·24	146	,,	Wetherby, Ribston H.	...	...
,,	Lexden Hill House	2·84	...	,,	Hull, Pearson Park	1·88	104
Suff	Haughley House	2·66	...	,,	Holme-on-Spalding	2·28	121
,,	Rendlesham Hall	2·65	146	,,	Felixkirk, Mt. St. John.	2·75	137
,,	Lowestoft Sec. School	1·91	114	,,	York, Museum Gdns.	2·15	121
,,	Bury St. Ed., WestleyH.	3·54	198	,,	Pickering, Hungate	2·82	135
Norf.	Wells, Holkham Hall	2·29	158	,,	Scarborough	2·78	139
Wilts	Porton, W.D. Exp'l. Stn	2·79	121	,,	Middlesbrough	...	...
,,	Bishops Cannings	3·20	138	,,	Baldersdale, Hury Res.	5·93	183
Dor	Weymouth, Westham.	3·48	143	*Durh*	Ushaw College	2·17	106
,,	Beaminster, East St.	4·38	126	*Nor*	Newcastle, Leazes Pk.	1·95	98
,,	Shaftesbury,Abbey Ho.	2·65	102	,,	Bellingham, Highgreen	4·11	144
Devon.	Plymouth, The Hoe	5·50	165	,,	Lilburn Tower Gdns.	2·78	134
,,	Holne, Church Pk. Cott.	14·31	232	*Cumb.*	Carlisle, Scaleby Hall	3·33	134
,,	Teignmouth, Den Gdns.	3·90	134	,,	Borrowdale, Seathwaite	20·00	159
,,	Cullompton	5·09	157	,,	Thirlmere, Dale Head H.	14·31	176
,,	Sidmouth, U.D.C.	3·07	...	,,	Keswick, High Hill	7·56	150
,,	Barnstaple, N. Dev.Ath	4·60	141	,,	Ravenglass, The Grove	4·11	123
,,	Dartm'r,Cranmere Pool	14·00	...	*West*	Appleby, Castle Bank	4·84	151
,,	Okehampton, Uplands.	9·64	189	*Mon*	Abergavenny, Larchf'd	4·23	125
Corn	Redruth, Trewirgie	6·34	150	*Glam*	Ystalyfera, Wern Ho.	11·17	177
,,	Penzance, Morrab Gdns.	5·53	146	,,	Treherbert, Tynywaun.	15·73	...
,,	St. Austell, Trevarna	6·90	161	,,	Cardiff, Penylan	5·78	157
Soms	Chewton Mendip	5·48	143	*Carm*	Carmarthen,M. & P. Sch.	8·36	186
,,	Long Ashton	4·90	171	*Pemb*	Pembroke,Stackpole Ct.	...	...
,,	Street, Millfield	2·69	114	*Card*	Aberystwyth	5·23	...
Glos	Blockley	3·04	...	*Rad*	BirmW.W.Tyrmynydd	10·42	165
,,	Cirencester, Gwynfa	3·92	156	*Mont*	Newtown, Penarth Weir	...	...
Here	Ross-on-Wye	2·63	109	,,	Lake Vyrnwy	...	...
Salop	Church Stretton	5·42	214	*Flint*	Sealand Aerodrome	3·28	176
,,	Shifnal, Hatton Grange	3·30	170	*Mer*	Blaenau Festiniog	15·71	168
,,	Cheswardine Hall	3·27	148	,,	Dolgelley, Bontddu	7·45	131
Worc	Malvern, Free Library	3·11	141	*Carn*	Llandudno	3·44	143
,,	Ombersley, Holt Lock.	...	...	,,	Snowdon, L. Llydaw 9..	27·40	...
War	Alcester, Ragley Hall	3·11	161	*Ang*	Holyhead, Salt Island	3·80	131
,,	Birminghm, Edgbaston	3·09	153	,,	Lligwy	5·44	...

Rainfall : January, 1938 : Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	5·16	154	*R&C* .	Achnashellach	13·33	139
Guern.	St.Peter P't.Grange Rd.	6·59	225	,, .	Stornoway,C.GuardStn.	7·11	145
Wig .	Pt. William, Monreith.	4·72	144	*Suth* .	Lairg........................	6·58	201
,, .	New Luce School.........	6·21	153	,, .	Skerray Borgie............	6·77	...
Kirk .	Dalry, Glendarroch......	8·39	151	,, .	Melvich......................	5·67	172
Dumf.	Dumfries, Crichton R.I.	4·97	164	,, .	Loch More, Achfary....	11·80	162
,, .	Eskdalemuir Obs........	9·23	171	*Caith* .	Wick	3·54	144
Roxb .	Hawick, Wolfelee........	4·83	151	*Ork* .	Deerness	5·26	152
Peeb .	Stobo Castle..............	4·79	160	*Shet* .	Lerwick Observatory...	6·08	143
Berw .	Marchmont House......	2·77	123	*Cork* .	Cork, University Coll...	4·59	114
E.Lot .	North Berwick Res.....	2·63	153	,, .	Roches Point, C.G. Stn.	4·78	115
Midl .	Edinburgh, Blackfd. H.	3·32	189	,, .	Mallow, Longueville....	6·65	171
Lan .	Auchtyfardle	7·08	...	*Kerry*.	Valentia Observatory...	7·28	133
Ayr .	Kilmarnock, Kay Park	5·75	...	,, .	Gearhameen...............	...	...
,, .	Girvan, Pinmore.........	6·99	148	,, .	Bally McElligott Rec...	5·88	...
,, .	Glen Afton, Ayr San....	10·23	201	,, .	Darrynane Abbey.......	5·28	105
Renf .	Glasgow, Queen's Park	7·76	232	*Wat* .	Waterford, Gortmore...	3·91	107
,, .	Greenock, Prospect H..	10·14	157	*Tip* .	Nenagh, Castle Lough.	6·50	164
Bute .	Rothesay, Ardencraig...	8·73	194	,, .	Cashel, Ballinamona....	6·03	161
,, .	Dougarie Lodge..........	5·01	116	*Lim* .	Foynes, Coolnanes......	7·18	190
Arg .	Loch Sunart, G'dale....	12·93	183	*Clare* .	Inagh, Mount Callan....	10·48	...
,,	Ardgour House..........	19·05	...	*Wexf* .	Gorey, Courtown Ho...	3·72	119
,, .	Glen Etive.................	21·41	204	*Wick* .	Rathnew, Clonmannon.	3·81	...
,, .	Oban........................	11·00	...	*Carl* .	Bagnalstown,Fenagh H.	4·01	128
,, .	Poltalloch..................	9·26	183	,, .	Hacketstown Rectory...	4·34	122
,, .	Inveraray Castle.........	18·38	224	*Leix* .	Blandsfort House.......	5·16	157
,, .	Islay, Eallabus............	6·74	144	*Offaly*.	Birr Castle................	4·39	155
,, .	Mull, Benmore...........	16·40	121	*Kild* .	Straffan House...........	3·98	155
,, .	Tiree	6·51	153	*Dublin*	Dublin, Phoenix Park..	2·53	111
Kinr .	Loch Leven Sluice.......	6·11	194	,, .	Balbriggan, Ardgillan...	3·14	137
Fife .	Leuchars Aerodrome...	3·47	191	*Meath*.	Kells, Headfort..........	4·43	141
Perth .	Loch Dhu..................	14·30	157	*W.M* .	Moate, Coolatore.........	4·60	...
,, .	Crieff, Strathearn Hyd.	6·22	154	,, .	Mullingar, Belvedere...	4·87	152
,, .	Blair Castle Gardens....	5·90	177	*Long* .	Castle Forbes Gdns......	4·53	136
Angus.	Kettins School...........	5·34	204	*Gal* .	Galway, Grammar Sch.	4·54	122
,, .	Pearsie House............	4·35	...	,, .	Ballynahinch Castle....	9·55	154
,, .	Montrose, Sunnyside...	2·88	145	,, .	Ahascragh, Clonbrock.	5·65	146
Aber .	Balmoral Castle Gdns..	4·62	167	*Rosc* .	Strokestown, C'node.....	4·27	136
,, .	Logie Coldstone Sch....	3·41	154	*Mayo*.	Blacksod Point..........	7·65	150
,, .	Aberdeen Observatory.	2·39	110	,, .	Mallaranny	8·74	...
,, .	New Deer School House	2·91	125	,, .	Westport House.........	6·04	130
Moray	Gordon Castle............	2·53	125	,, .	Delphi Lodge.............	14·09	142
,, .	Grantown-on-Spey	3·22	133	*Sligo* .	Markree Castle...........	6.04	155
Nairn.	Nairn	2·48	125	*Cavan*.	Crossdoney, Kevit Cas..	5·08	...
Inv's .	Ben Alder Lodge.........	12·89	...	*Ferm* .	Crom Castle...............	5·56	167
,, .	Kingussie, The Birches.	5·21	...	*Arm* .	Armagh Obsy............	3·86	153
,, .	Loch Ness, Foyers	...	...	*Down*.	Fofanny Reservoir......	5·56	...
,, .	Inverness, Culduthel R.	3·89	153	,, .	Seaforde	4·24	135
,, .	Loch Quoich, Loan......	24·35	...	,, .	Donaghadee, C. G. Stn.	3·76	148
,, .	Glenquoich................	20·79	151	*Antr* .	Belfast,Queen's Univ....	4·73	165
,, .	Arisaig House............	8·40	135	,, .	Aldergrove Aerodrome.	3·55	130
,, .	Glenleven, Corrour......	...	...	,, .	Ballymena, Harryville.	5·25	141
,, .	Fort William, Glasdrum	15·50	...	*Lon* .	Garvagh, Moneydig....	5·12	...
,, .	Skye, Dunvegan.........	10·46	...	,, .	Londonderry, Creggan.	7·02	195
,, .	Barra, Skallary..........	6·07	...	*Tyr* .	Omagh, Edenfel.........	5·88	166
R&C.	Tain, Ardlarach..........	4·30	152	*Don* .	Malin Head...............	5·07	154
,, .	Ullapool	6·93	151	,,	Dunkineely................	6·17	...

Climatological Table for the British Empire, August, 1937

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
	Mean of Day M.S.L.	Diff. from Normal.	Absolute.		Mean Values.				Mean.			Am'nt.	Diff. from Normal.	Days.	Hours per day.	Percentage of possible.
			Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.							
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	In.	In.			
London, Kew Obsy.	1018·2	+ 2·9	85	50	74·1	57·2	65·7	+ 4·0	57·7	86	6·6	2·98	+ 0·74	4	6·8	47
Gibraltar	1014·7	− 1·8	89	64	79·8	68·0	73·9	− 2·1	67·6	86	4·5	0·02	...	1	...	...
Malta	1014·3	− 0·5	91	70	85·2	73·6	79·4	+ 0·3	72·5	76	2·2	0·02	− 0·12	1	10·9	81
St. Helena	1016·0	− 1·4	63	53	60·4	54·7	57·5	+ 0·5	55·5	94	10·0	2·01	− 0·48	14	...	...
Freetown, Sierra Leone	1012·9	+ 1·8	86	70	80·7	72·2	76·5	...	74·3	90	8·7	39·77	+ 3·20	30	...	...
Lagos, Nigeria	1013·9	+ 0·9	86	70	81·9	74·1	78·0	+ 0·1	73·6	88	8·8	1·42	− 1·22	9	4·9	40
Kaduna, Nigeria	1011·4	...	89	66	82·4	68·6	75·5	+ 1·6	70·6	90	8·5	9·88	− 2·44	21	4·8	39
Zomba, Nyasaland	1017·1	+ 0·2	79	47	73·8	54·5	64·1	− 0·8	59·5	75	4·7	1·42	+ 1·05	6	...	...
Salisbury, Rhodesia	1020·5	+ 0·4	79	39	72·2	45·3	58·7	− 1·5	49·4	50	1·0	0·03	...	1	9·2	80
Cape Town	1021·2	+ 0·9	89	40	66·8	49·0	57·9	+ 2·3	50·6	84	5·0	1·37	− 2·00	10	...	...
Johannesburg	1021·3	+ 1·7	74	35	68·1	45·0	56·5	+ 2·1	43·8	42	0·7	0·00	− 0·51	0	9·7	87
Mauritius	1021·1	+ 0·5	77	54	75·0	61·5	68·3	− 0·2	64·6	72	5·1	2·96	+ 0·71	21	8·5	75
Calcutta, Alipore Obsy.	999·9	− 1·1	92	76	88·6	79·4	84·0	+ 0·8	79·7	89	9·0	14·10	+ 0·72	16*	...	...
Bombay	1005·9	0·0	87	75	85·3	76·8	81·1	+ 0·3	76·6	86	8·9	5·45	− 9·00	15*	...	...
Madras	1004·9	− 0·6	99	72	93·9	77·5	85·7	− 0·3	76·6	75	6·6	6·99	+ 2·45	10*	...	...
Colombo, Ceylon	1008·8	− 0·5	87	74	85·3	78·5	81·9	+ 0·7	76·9	76	7·3	2·12	− 1·12	13	6·7	55
Singapore	1009·1	− 0·4	89	73	86·4	78·4	82·4	+ 1·3	77·4	79	5·7	4·55	− 3·40	14	7·3	61
Hongkong	1004·2	− 0·6	93	76	86·1	79·0	82·5	+ 0·4	78·8	85	8·6	14·35	− 0·05	23	4·0	31
Sandakan	1008·3	...	92	73	89·4	75·2	82·3	+ 0·5	76·8	83	7·9	6·13	− 1·76	12	...	...
Sydney, N.S.W.	1019·5	+ 1·3	72	42	64·8	48·6	56·7	+ 1·7	51·4	74	4·9	4·15	+ 1·18	15	6·5	60
Melbourne	1019·4	+ 1·4	73	34	61·3	45·2	53·3	+ 2·3	47·9	73	7·0	1·31	− 0·56	13	4·3	41
Adelaide	1018·6	− 0·6	72	39	63·0	47·3	55·1	+ 1·1	50·6	71	7·9	3·40	+ 0·86	17	4·2	39
Perth, W. Australia	1018·1	− 0·8	74	39	64·3	48·2	56·3	+ 0·3	50·3	64	6·0	6·80	+ 1·15	18	6·0	55
Coolgardie	1018·8	− 0·5	75	33	63·3	39·5	51·4	− 2·2	45·3	65	2·8	0·63	− 0·36	6	...	...
Brisbane	1020·2	+ 1·0	78	44	69·8	51·8	60·8	+ 0·4	55·3	70	3·1	1·40	− 0·61	11	7·1	64
Hobart, Tasmania	1017·9	+ 4·5	67	32	57·3	43·0	50·1	+ 2·1	44·2	72	4·9	0·63	− 1·20	12	5·3	51
Wellington, N.Z.	1022·5	+ 7·4	61	37	54·3	43·0	48·7	+ 0·1	45·7	79	8·4	1·03	− 3·46	8	4·3	41
Suva, Fiji	1013·6	− 0·6	85	63	78·6	69·5	74·1	+ 0·5	70·6	87	7·2	11·46	+ 3·17	23	4·1	35
Apia, Samoa	1011·2	− 1·1	86	70	83·8	74·7	79·3	+ 1·5	75·1	78	5·7	6·26	+ 2·63	13	7·2	61
Kingston, Jamaica	1013·2	− 0·3	93	71	89·1	73·9	81·5	0·0	72·9	83	3·6	4·76	+ 1·21	10	8·6	68
Grenada, W.I.	1011·6	− 1·0	88	70	86	74	80	+ 0·3	73	74	5	8·58	− 0·75	22	...	...
Toronto	1017·6	+ 2·2	89	53	81·8	63·2	72·5	+ 5·3	65·1	86	5·5	2·89	+ 0·10	9	7·8	56
Winnipeg	1012·4	− 0·8	97	45	81·7	57·0	69·3	+ 5·5	56·7	88	4·3	2·12	− 0·04	11	8·7	60
St. John, N.B.	1017·0	+ 1·7	87	51	71·4	56·8	64·1	+ 3·5	59·9	89	7·5	1·66	− 2·20	16	6·8	48
Victoria, B.C.	1017·6	+ 0·7	79	48	67·1	51·6	59·3	− 0·4	55·5	80	4·9	1·55	+ 0·91	10	8·6	60

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

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The Warming Arctic

In recent years attention is being directed more and more towards a problem which may possibly prove of great significance in human affairs, the rise of temperature in the northern hemisphere, and especially in the Arctic regions. This warming up has been especially noticeable in the winter of 1937–8, as shown by the four charts of Fig. 1, which represent the departures from " normal " during the months of October to December, 1937, and January, 1938. All of them show a marked excess of temperature especially in Arctic Russia, culminating in January. February also shows an excess of 10°F. in the Barents Sea and northern Sweden. Moreover, the normals with which the current observations are compared are themselves limited to two or three decades of the present century, and it is safe to say that had they covered a longer period, the departures would have been still greater.

A study of the problem has recently been published by R. Scherhag.[*] At Spitsbergen the average winter (Nov.–March) temperature for 1931–5 was 16° F. higher than for 1911–20, and in the neighbouring seas the edge of the ice in late summer has retreated an average distance of some 150 miles. The Spitsbergen branch of the North Atlantic Current has greatly increased in strength and the surface layer of cold water in the Arctic Ocean has decreased from 200 to 100 metres in thickness. Scherhag also finds that the temperature of the Gulf Stream in 1926–33 was about 0·75° F. higher than in 1912–8, and there has been a similar rise in the surface temperature of the English Channel.

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[*] Die Erwärmung der Arktis. *Copenhague, J. Cons. int. Explor. Mer*, 12, 1937, pp. 263–76.

Scherhag explains the rise of temperature in high latitudes quite simply by an increase in the strength of the atmospheric circulation. In the last decade the mean pressure has decreased considerably in the Icelandic and Aleutian lows and increased in the sub-tropical belt of high pressure. There has been an increase in the strength of the westerly winds of temperate latitudes which has driven more warm surface water into the Arctic Basin. He points out, however, that the zones both of greatest decrease of pressure and of marked rise of temperature have moved gradually northward during the past 50 years. In central and western Europe the main rise of temperature began about 1900, in the Arctic not until 1922. On the basis of C. Easton's coefficients of winter temperatures since 1235, he considers that this variation in the circulation has a periodicity of about 220 years and that the crest of the warm period is already past. The latter conclusion seems to be borne out by the variations of temperature at Oxford,* where the maximum of the smoothed curve of winter temperatures occurred in the 20 years 1909–28.

Variations of winter temperature alone are not a very good basis for determining variations in the strength of the general circulation. Observations of wind direction in the British Isles show that about 220 years ago the westerlies in this country were less persistent than in the nineteenth century, and other data suggest that the last maximum of westerly winds lasted from about 1300 to 1550.† The present maximum began about 1810 and the downward trend of temperature at Oxford during the past few years may be only a minor oscillation.

Attributing the recent period of warm winters to an increase in the strength of the atmospheric circulation only pushes the problem one stage further back, for we should still have to account for the change of circulation. Moreover, it is almost equally plausible to regard the change of circulation as a *result* of the warming of the Arctic, for open ice conditions in the Arctic Ocean are favourable to the formation of depressions. More probably the increased circulation is both cause and effect of the warmed Arctic ; high temperature causes storminess and decrease of pressure in high latitudes, which in turn is associated with stronger west winds in middle latitudes, driving an excess of warm sea water into the Arctic and raising the temperature still further. Again, the decrease in the area of ice means less ice-cooled water sinking to the ocean floor, a higher temperature in the upwelling water off the west coast of Africa, a warmer Gulf Stream (actually observed) and more heat carried into the Arctic. Both these possible processes, once begun, are cumulative in their action, and reinforce each other. In this connexion it is interesting to note that, as illustrated in Fig. 1, the warming up appears to have been greatest on the coast of western Siberia, just where the warm current from the Atlantic is reaching the limit of its influence, and consequently where a strengthening of this current might be expected to have the greatest effect on temperature. The main objection to this suggestion is

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* Lilian F. Lewis. Variations of temperature at Oxford 1815–1934. *London, Prof. Notes, met. Off.* 5, No. 77, 1937.

† *London, Quart. J. R. met. Soc.*, 60, 1934, p. 165.

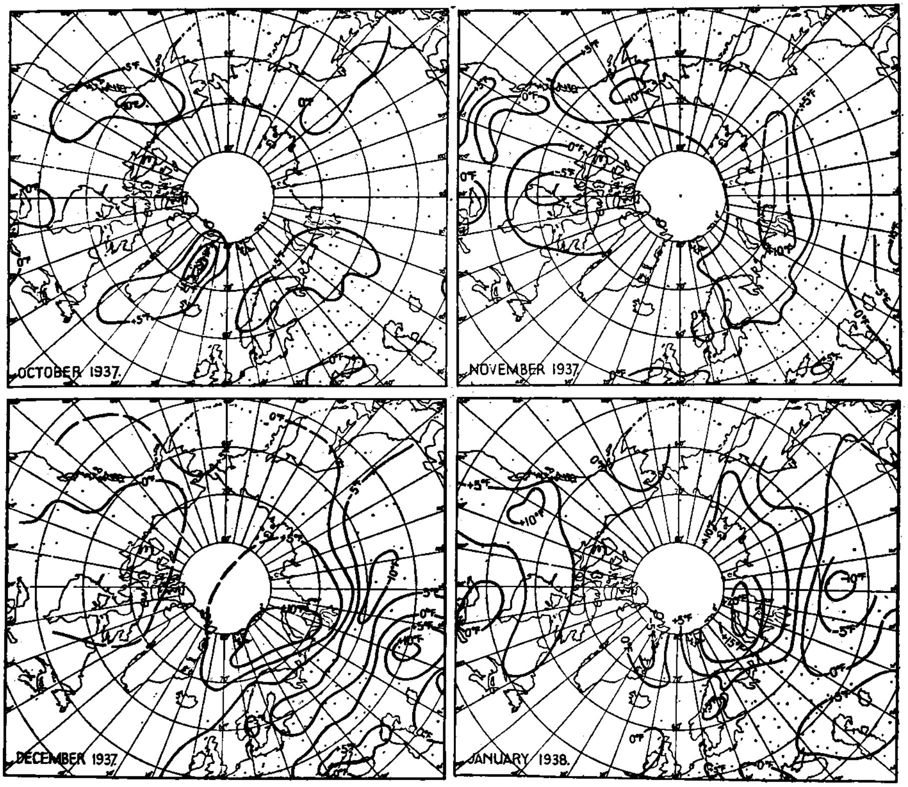

FIG. 1—DEVIATIONS OF TEMPERATURE FROM NORMAL.

that the warming up apparently began not in the Arctic but in middle latitudes, especially in central Europe,* and two decades elapsed before it penetrated far beyond the Arctic circle. At Spitsbergen at least, the rise occurred in two stages, the winters of 1922–3 to 1924–5 being warm, those of 1925–6 to 1929–30 somewhat cooler, and those of 1930–1 onwards warmer than the first group, while even during the last eight winters there has been a steady rise.

It may also be objected that the atmospheric circulation depends on the difference of temperature between low and high latitudes and hence should be weakened instead of strengthened by a warming of the Arctic. This has apparently happened in low latitudes, as is shown by the rise of pressure at tropical stations mentioned by Scherhag, and also by the decreasing wind velocity at St. Helena, but a weakening of the circulation in low latitudes may not be incompatible with a local strengthening in middle latitudes, and it is the latter which would be mainly operative in raising the temperature of the Arctic regions.

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* *Met. Mag., London,* 57, 1922, p. 203.

Whatever the mechanism, the rise of temperature did begin, and presumably had a cause, though it is conceivable that it arose spontaneously in the incessant kaleidoscope of temporary pressure distributions. One possible cause was put forward at the February meeting of the Royal Meteorological Society by G. S. Callendar, namely, the addition of carbon dioxide to the air by consumption of fuel (*see* p. 35), but the effects of this addition seem to require further examination. There have been great climatic oscillations before this, even since the last Ice Age, about the causes of which we are quite ignorant.

C. E. P. BROOKS.

Meteorology in Ceylon

The *Ceylon Journal of Science* was founded in 1924 by the Ceylon Government to provide facilities for the publication of papers dealing with scientific researches, which are being carried out in Ceylon. The journal is divided into six sections, of which Section E is devoted to Meteorology. Prior to 1924 such material was published as *Bulletins of the Colombo Observatory.*

The first article of the volume under review* compares the intense falls of rain experienced in Ceylon with those of this country, as classified in *British Rainfall,* 1935,† by constant frequency graphs. The frequency of occurrence of intense falls for certain specified limits are given for two stations which have annual averages of 91 and 163 in. respectively. The rainfall in Ceylon is largely orographical and heavier than that in most parts of the British Isles. The amounts which occur at Colombo on one day per year during 10 to 120 minutes correspond closely with falls in the British Isles defined by Mill in *British Rainfall,* 1908, as "very rare". These "very rare" falls have been shown to occur in the British Isles with a frequency of about "one day in 160 years" for durations of 22 to 110 minutes. For Ceylon there is apparently "an upper limit to the rate at which rain can fall . . . . The strong gusts of wind that so frequently precede and accompany heavy rain suggest that the following rain forces the air beneath it to spread out, and that these outward gusts, in their turn, spread out the rain. The heavier the rain, the greater the area over which it might be dispersed, and hence the possibility of an automatic upper limit to rainfall intensities". It will be interesting to learn whether additional observations there confirm this theory.

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* Colombo, Ceylon *J. Sci.* (*E*). Vol. II, Part 2, 1937.

† Classification of heavy falls in short periods. By E. G. Bilham. *London, Brit. Rainf.*, 1935, p. 262.

The second paper gives an account of heavy rains during the seven days May 20th to 26th, 1933, in Ceylon, when unusually intense rains are attributed to convergence of different air streams. The largest entry for any individual day was 14·45 in. The maximum recorded for any day in the British Isles is 9·56 in.

Another paper includes tables of the saturation deficit, in millibars, for the sixteen principal climatological stations in Ceylon. In each case monthly values are given for about eight years. Values are given for the saturation deficit for 9h. 30m., 15h. 30m., and night. The values at night are usually low, the differences between night and afternoon being particularly marked inland and in the lower country. At the higher stations the saturation deficit is usually lower at 15h. 30m. than at 9h. 30m. "due probably to the joint effect of the moisture brought in by converging sea-breezes and the fall in temperature caused by the resultant early clouding". The mean values for the year vary from 3·0 mb. to 8·2 mb., compared with 1·7 mb. at Eskdalemuir and 2·8 mb. at Kew. In London the early morning value tends to remain the same throughout the year, while the afternoon value is greater in summer than in winter. The range is from 1·0 mb. in the early morning in January to 10·0 mb. in the early afternoon in July. In Ceylon the means for certain months for 15h. 30m. exceed 20 mb.

The fourth article is, from many aspects, a more detailed discussion of earth temperatures than has been carried out for any station in the British Isles. It gives monthly means of earth temperatures at depths of 1, 2, 3, 4, 5 and 10 ft. for the fifteen years 1919 to 1933 at Colombo Observatory. Diurnal variations are not noticeable at 2 ft. or below. It was also found that the mean of readings at 9h. 30m. and 15h. 30m. (Ceylon Standard Time) could be taken, with sufficient accuracy, to represent the mean for the 24 hours. The annual mean temperature at each depth was approximately 85½° F. and 5° to 5½° F. higher than the mean air temperature. At Camden Square, London, the mean annual temperatures at 1 ft., 4 ft. and 10 ft. are almost identical with the mean air temperature 50° F., the temperature at 10 ft. being about ½° F. less than those at 1 ft. and 4 ft. At Colombo, as at Camden Square, the range in the monthly values decreases appreciably as the depth increases. At Colombo, the curves of mean monthly earth temperature show two maxima and two minima. This is related to the sun's zenith distance from Colombo at mean noon (Colombo being at 7° N.). There are, however, three other factors. During the first half of the year (*a*) the duration of sunshine is greater, (*b*) the rainfall is less, and (*c*) the diurnal variation of rainfall is more marked, the bulk falling in the evening, resulting in a reduced effect on the solar heating of the ground. The spring maximum of earth temperature is, therefore, higher than the autumn maximum and the summer minimum than the winter minimum. The lag in the various phases is about 4 to 5 days per foot. The effect of rain water percolating through the ground is also studied. In general the effect is to decrease the temperature on the following day but the decreases are not proportional to the amounts of rainfall.

In order to test whether it would be an advantage to have rain-gauges painted white in tropical countries like Ceylon, where evaporation is considerable, experiments were carried out with rain-gauges painted white and black respectively. When this experiment was carried out in this country* the comparison was vitiated by the amount of rain held up on the varnished surface and subsequently evaporated. In Colombo this difficulty was overcome by adding given quantities of water to the inner cans of 2½ in. diameter and exposing the gauges during 40 to 50 hours of sunshine without any rain falling. The loss per sunny day was about ·005 in. in the case of the white gauge and ·01 in. with the black gauge. Thus while the losses are small, there is a slight advantage in using white gauges. Reference is made to the experiments carried out by Dr. A. J. Bamford,† which showed that the loss by evaporation is mainly a function of the container. In these circumstances the problem of devising a suitable white rain-gauge, i.e. without painting the surface of the funnel, has not been pursued.

The source of light from the Milne-Shaw seismograph at the Colombo Observatory is a 6-volt electric bulb, worked off a 4-volt accumulator battery. It occasionally happens that the battery runs down unexpectedly, causing a loss of record which becomes considerable when the failure occurs at night. In order to overcome this difficulty an air thermometer is mounted by the side of the electric bulb and by a simple device an electric bell is rung when the temperature falls. Even when the supply was obtained from the mains this device, which is explained in detail, was found to be advantageous.

The last note in the volume deals with a type of pen which has been found satisfactory in giving a continuous record in self-recording anemometers. The pen is triangular in shape, with a small cylinder soldered into one side, and is nearly filled with a pad of cotton wool.

It is clear from these papers that much useful meteorological work is being carried out at Colombo Observatory under the Directorship of Dr. H. Jameson.

J. Glasspoole.

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*Experiments with rain-gauges with black and white funnels. *London, Brit. Rainf.*, 1929, p. 284.

†*Met. Mag., London*, 57, 1922, p. 240 and 65, 1930, p. 81.

OFFICIAL NOTICE

Sir George Simpson, K.C.B., F.R.S., will retire from the position of Director of the Meteorological Office in September next, and the Secretary of State has appointed Mr. N. K. Johnson, M.Sc., A.R.C.S., to succeed him. Mr. Johnson is at present Chief Superintendent of the Chemical Defence Research Department, War Office.

Royal Meteorological Society

The monthly meeting of the Society was held on Wednesday, February 16th, at 49, Cromwell Road, South Kensington. Dr. B. A. Keen, F.R.S., F.Inst.P., President, was in the Chair.

Mr. E. W. Barlow, B.Sc., F.R.A.S., described the auroral display of January 25th–26th, 1938, and Prof. S. Chapman, M.A., D.Sc., F.R.S., gave a short account of the physics of aurora.

The following papers were read and discussed :—

G. S. Callendar.—The artificial production of carbon dioxide and its influence upon surface temperature.

By fuel combustion man has added about 150,000 million tons of carbon dioxide to the air during the past half century. The author estimates from the best available data that approximately three quarters of this has remained in the atmosphere.

The radiation absorption coefficients of carbon dioxide and water vapour are used to show the effect of carbon dioxide on " sky radiation ". From this the increase in mean temperature, due to the artificial production of carbon dioxide, is estimated to be at the rate of 0·003° C. per year at the present time.

The temperature observations at 200 meteorological stations are used to show that world temperatures have actually increased at an average rate of 0·005° C. per year during the past half century.

R. A. Hamilton.—The Oxford Expedition to North-East Land, 1935–6. General meteorology.

The expedition maintained a station for a year at 80° 23′ N. 19° 31′ E. on the north-west coast of North-East Land and other stations for shorter periods on the west coast and on the ice cap in the interior of the country.

This paper gives monthly means and extreme values of the usual meteorological elements as observed at these various stations together with a general comparison between them.

Although there is reason to believe that the winter was an unusually mild one, the observations seem to disprove the tradition of continual gales, a wind velocity of 12 to 14 m.p.h. being maintained during the dark time. Sudden large fluctuations in temperature occurred in the winter and spring, changes of 30° F. being recorded in one day. In spite of the high latitude, temperatures above 15° F. were recorded during every month of the year. An almost constant feature of the summer weather was the mist which enveloped the ice-cap station (1,700 ft.) and which was usually observed about 300 ft. up on the hills near the Base Camp.

G. Manley, M.A., B.Sc.—Meteorological observations of the British East Greenland Expedition 1935–6, at Kangerdlugssuak.

Systematic and detailed meteorological observations were maintained by the British East Greenland Expedition, 1935–6, under the leadership of L. R. Wager. The expedition's coastal base was at Kangerdlugssuak (68° 10′ N.) in a region, previously little known, which is of distinct meteorological interest. The records have been discussed in some detail and compared with those of Danish stations and those of a previous Norwegian expedition; the courtesy and help of the Danish and Norwegian authorities is gratefully acknowledged. The British observations, reduced and tabulated, are available at the Royal Meteorological Society, summaries only are appended to the paper, by reason of lack of space. Conclusions are reached with regard to the meteorological characteristics of the region, notably the occurrence of fjord gales and precipitation. It is hoped that the general discussion of this excellent set of observations will be of value to others working on the problems of Greenland meteorology. Maps and photographs will be found, accompanying the general account of the expedition, in the *Geographical Journal*, Vol. 90, November, 1937.

R. M. Poulter.—Cloud forecasting: the daily use of the tephigram.

For air-survey work and other specialised daylight flying it is important to know for some hours ahead in fine weather the amount of the sky that will be covered by cloud and the height at which the cloud will exist. Readings of the dry- and wet-bulb thermometers at 50 mb. intervals provide information which, when plotted on a tephigram or similar diagram, enables a forecaster to predict with useful accuracy the amount, height and thickness of clouds during the day. Temperature and dew-point at 4 ft. in the forecast area and the probable rise of temperature are required to give the height of potential condensation, while the relation between the condensation temperature and the temperature of the environment is the criterion for cloud formation.

Cloud thickness is judged by the relation between the saturation adiabatic through the condensation point and the actual temperatures above, while cloud amount is estimated by the relative humidity of the environment at the condensation level.

The application of this technique to the various situations met in day-to-day forecasting is described and illustrated.

S. K. Banerji, D.Sc.—Does rain play any part in the replenishment of the earth's negative charge? (Read in title only.)

A number of thunderstorms passed over the Bombay Observatory and the data of rainfall and of charge, as given by Simpson's apparatus are here discussed. The rainfall brings down definitely more negative than positive charge.

Correspondence

To the Editor, *Meteorological Magazine*

Persistent Fog

It is, I think, unusual for fog.to persist all day in the country outside London as early as October 21st. The persistence of fog in the area north of London on October 21st, 1937 therefore deserves mention.

In the early morning the fog appears to have been generally thick, but in the northern suburbs it cleared considerably during the forenoon and the sun shone. North of Mill Hill and east towards Hatfield the fog did not clear, the visibility about 2 p.m. still being of the order of 100 to 200 yards and the sun entirely obscured. The fog persisted towards the north also and was if anything thicker on rising ground than on low ground. This condition continued at least to the junction of the North Orbital Road and Watling Street, north to London Colney. Conditions were similar along the North Orbital Road towards the west for two or three miles, and then the sun became just visible through the fog and visibility improved and continued to improve towards the west, and the sun began to shine when the Watford By-Pass was reached.

In the Chilterns, towards Chesham, visibility was generally better—never I think less than 1,000 yards and generally 2,000 or 3,000 yards. The sunshine was continuous though not powerful. Visibility continued to be good through Chesham to Rickmansworth, through Pinner and Stanmore, but fog was again met on the Watford By-Pass where the visibility was in places only about 30 yards; this was about 4 p.m. It was distinctly patchy and further patches of fog were met between Mill Hill and the junction with the North Circular Road: La Déliverance.

It was quite clear from the conditions experienced that the fog north of London was not fog drifting from London northwards but the fog of the previous night which was persisting. I could find out no satisfactory reason to explain the simultaneous facts of its persistence in the region mentioned and its absence west of the Watford By-Pass. After examining the synoptic charts and the upper winds and discussing the matter with Mr. Absalom I am led to suggest that the pall of smoke and fog over London on the night of October 20th–21st had drifted northwards in the early morning and forenoon and formed a screen which prevented the sun from dissipating the fog in the area covered by this pall. The direction of the upper wind was about 160 degrees and if the pall drifted with this upper wind that would have left the area of the Chilterns to the west of the pall and would explain the clearing of the fog there and the sunshine in the afternoon of the 21st. This clearing in the afternoon was quite distinct from the clearing which took place in the morning of the 22nd.

By 6 p.m. on the 21st the Hunton Bridge, Berkhamstead Valley, was again filled with fog. It seems a degree worse than ironical that the London surface fog should have been dispersed on the 21st while its upper pall of smoke and fog should have been responsible for the persistence of fog over the fair countryside.

E. GOLD.

October 22nd, 1937.

Sea Disturbance at Coastal Stations

With reference to the article in the December issue, I think it would be difficult to convince any sailor that the sea disturbance in an off-shore westerly gale at Spurn Head could be in any way comparable to that rolling home at Tiree or the Scillies under similar conditions with the whole Atlantic behind it.

At the former—especially with a weather-going spring flood tide in the Humber Estuary—one might expect a nasty broken short sea, but in seaman's parlance it would amount to little more than a " wind-lop " and would probably cause but little motion to a paddle-steamer.

At Scilly or Tiree one would expect a 1st class battleship to be " taking it green " over the bows.

JACK BLAKE.

Monckton House, Alverstoke, Hants, December 26th, 1937.

The article by Mr. Donald L. Champion on " Wind Velocity and Sea Disturbance " in last month's issue raises several points which appear to call for clarification.

Firstly, can the personal element in estimating sea disturbance be entirely disregarded in such a set of observations ? It is not made clear in the article if *both* the daily observations at 7h. and 18h. were utilised in the preparation of the isopleths, but if such be the case is it really safe to accept such estimates taken on a dark night from low elevations such as Spurn Head or Point of Ayre ? Must there not be a subconscious connection in the observer's mind on such occasions collating say a NW. wind force 6 at Point of Ayre with a sea disturbance of 4.

Secondly, do observers at land stations differentiate between swell and wind waves when reporting sea disturbance ? There must be many occasions particularly at the " deep water " stations Scilly and Tiree where swell is of much greater amplitude than would be warranted by wind force alone. Such instances might account for Mr. Champion's conclusion regarding gales from SE. at Tiree causing waves exceeding 10 ft. amplitude. Would not these waves probably be swell from the Atlantic formed by the winds blowing in the right front of a disturbance moving from south-west or west ? From a map it seems most unlikely that SE. winds even of gale force would have sufficient " fetch " to cause such high seas at Tiree.

Thirdly, does not the fact that both Spurn Head and Point of Ayre are at positions where tidal currents meet make possible over-estimation of sea disturbance likely ? Such situations are notorious at certain states of the tide for the pyramidal formation of the waves, and this apart from any wind influence must have some effect on the results. Also the state of the tide must surely make a difference to the state of the sea at Spurn. At dead low water there must surely be a reduction in the "fetch" down the Humber owing to the sandbanks.

Lastly, as regards the greater amplitude ratio of wave to wind in the North Sea, it is surely hardly safe to venture such a conclusion from data taken from a single observing point at Spurn Head. To obtain a truer estimate would not the records of sea disturbance at one of the light-ships, e.g. Outer Dowsing, give a more correct result, and as regards the big Atlantic seas, do they not batter themselves to destruction on the west Irish and Outer Hebridean coasts ?

FRANK EDWARDS.

"Trevor," Greave, Romiley, Cheshire, December 29th, 1937.

It must freely be admitted that, as pointed out by Messrs. Blake and Edwards, the results published on the above subject in the December issue of this magazine are somewhat disconcertingly contrary to expectation, but the following points should particularly be noted :—

1. In all eye observations, the personal element is doubtless more pronounced than in instrumental measurements, but the fact that the 18h. observations are included should not have any marked effect, because in winter the darkness frequently is just as intense at 7h. as it is at 18h. ; also, in dealing with the estimation of wave amplitude the observer is noting a phenomenon of considerable dimensions—even in comparative darkness one must admit that errors of several feet are extremely unlikely to be made by routine observers.

Furthermore, even if "subconscious connexion in the observer's mind" were made between a given wind and resultant wave amplitude, it would naturally be based on previous observations made in broad daylight, and there is little reason to assume that the amplitude for a given wind would be any different during hours of darkness.

2. If the waves exceeding 10 ft. in amplitude observed with south-easterly gales at Tiree were due to Atlantic "swell," it is very difficult to understand why a corresponding swell was not observed with winds of equal or higher velocity from the west.

In the case of the intense depression which developed in mid-Atlantic and moved rapidly ENE. towards the Faeroes on the night of December 15th, 1936, giving an almost "straight" fetch for SW. winds of over 1,000 miles across the open sea towards our western shores, it will be noted that at the height of the storm at

18h. (*see* Fig. 1), in spite of " precipitous " seas at Blacksod Point, there was no apparent swell at either Tiree or Scilly, and at Malin Head the sea was described as " slight." At all stations on the east coast of Great Britain except Spurn Head, the seas were slight or moderate ; yet at Spurn, where obviously no Atlantic swell could ever reach, the sea was described as " rough," which seems to indicate something more than " wind-lop."

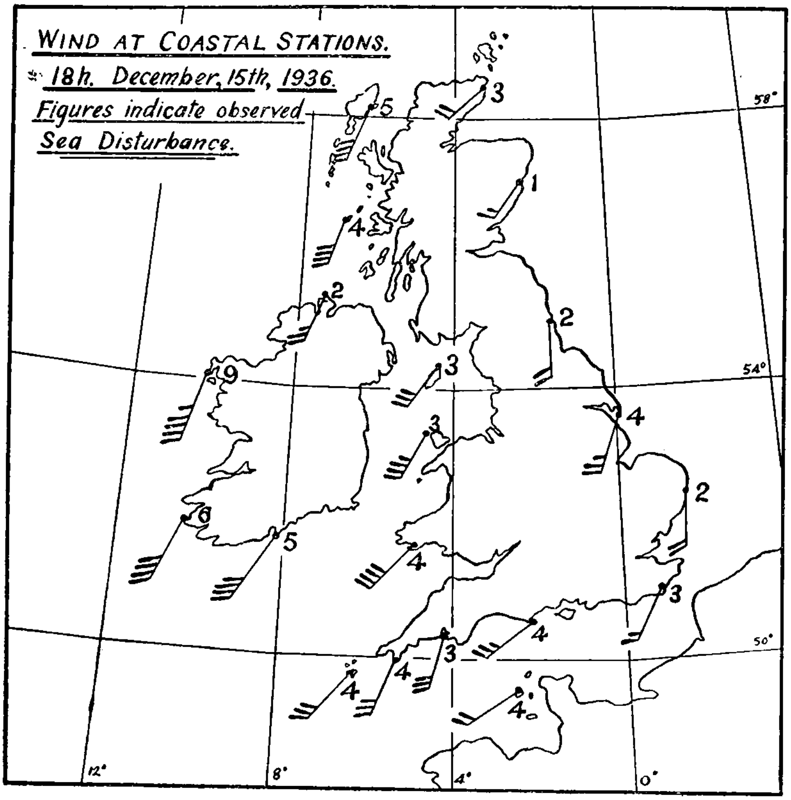

WIND AT COASTAL STATIONS.
18h. December, 15th, 1936.
Figures indicate observed Sea Disturbance.
58°
54°
50°
12°
8°
4°
0°
3
5
1
4
2
2
3
9
3
4
2
6
5
4
3
3
4
4
4
4

FIG. 1.

3. One must agree that where tidal currents meet, the sea disturbance may be increased, but if in this particular case the increased disturbance at Spurn is due to this cause, it is certainly not shown by any marked increase in amplitude at Point of Ayre. It is true that sandbanks at low water must influence the resultant sea disturbance at Spurn, but there is no reason to assume that all gales in any year at this station occur at high water, which makes the higher mean amplitude observed at this station all the more perplexing.

4. Estimates of sea disturbance from points in the North Sea, such as the Outer Dowsing, Outer Gabbard, etc., would certainly give a fairer computation of the roughness of the *open* North Sea, but one could hardly describe such places as " coastal " stations. It is true that big Atlantic seas may, and probably do, " batter themselves to

destruction" on the west coasts of Ireland and the Outer Hebrides, but again, one must admit that neither Tiree nor the Scillies are sheltered from Atlantic rollers from the west; and one wonders why, with precipitous seas at Blacksod on the night of December 15th, 1936, the seas at Tiree and Malin were only observed to be "rough" and "slight" respectively.

DONALD L. CHAMPION.

7, Robinson Avenue, Goffs Oak, Herts, January 8th, 1938.

Fine coloured Parhelion

On December 12th, 1937 between 3.10–3.20 p.m., a fine mock sun, with full prismatic colours, appeared in the west-south-west at 22 degrees from the sun. This parhelion appeared to be "right," or north of the true sun and was apparently square in shape as if it were a segment cut from a rainbow. The prismatic colours were perfect from the red on the "left" or south side, to violet on the "right" or north limb of the mock sun. The mock sun which normally should have been seen to the "left," or south side of the true sun was obliterated by dark rain clouds. As is usually the case, stormy weather followed this phenomenon.

DONALD W. HORNER.

51, Manor Road, Weston-super-Mare, January 8th, 1938.

Dispersal of Cloud by an Aeroplane

An interesting phenomenon was witnessed here at 14h. 25m. G.M.T. on Friday, November 26th. The sky at the time was covered with very thin stratocumulus cloud and an aeroplane flying horizontally in it was observed to be leaving a path, entirely devoid of cloud. The length of the path was at least half a mile and the width seemed to correspond with the wing span of the aeroplane. The most remarkable feature, however, was the clean-cut nature of the sides of the path, which remained very distinct for a duration of one minute, after which the cloud gradually closed in. The track of the aeroplane was, however, still discernible, and appeared as a long thin cylinder of cloud with a slight roll form which enabled it to be distinguished from the surrounding cloud.

Pilot balloon observations made immediately after the occurrence showed that the cloud was at a height of 3,000 ft. The pilot concerned confirms this height, and states that the layer of cloud was extremely thin. There was a calm at the surface and winds of less than 7 m.p.h. up to 3,000 ft.

The upper air record for Mildenhall at 13h. showed that there was a strong inversion above the cloud layer. In this case any mixing brought about by the propellor would cause a certain amount of heating, but it seems impossible that this could have given the observed effects.

A suggested explanation is that the cloud was swept aside mechanically by the propellor, not closing in immediately behind the machine owing to the presence of the exhaust gases, and to the fact that there was practically no wind.

T. H. KIRK.

Meteorological Station, R.A.F., Dishforth, Thirsk, Yorkshire, December 2nd, 1937.

NOTES AND QUERIES

St. Elmo's Fire in Egypt

In the *Meteorological Magazine* for May, 1937, appears a letter from Mr. W. D. Flower, Sudan Government Meteorologist, describing the occurrence of St. Elmo's fire at Khartoum. Sparks passed between the finger tips of the observer and the bed blankets. He states that this is a common occurrence in the winter, and is due to the accumulation of electricity produced by friction of sand particles raised by the wind.

I have received the following letter from Mr. G. W. Murray, of the Desert Survey of Egypt, describing a striking exhibition of St. Elmo's fire at Aswan. It was in this case not due to electrification of sand particles, as for some days the air had been very clear, but to induction from charged clouds. About that time there was considerable cumulonimbus ; the air was dry, but not so dry as usual at the time of year, humidity being 50 per cent at 8h. and 40 per cent at 14h. on the 5th compared with normal values of 45 per cent and 25 per cent respectively, and there was light rain just before 14h.

"Aswan Dam,
February 6, 1938.

Dear Sutton,

We are at present in camp about one kilometre west of Aswan Dam. The following electrical phenomena took place yesterday and today :

1. My assistant inspector, Khalaf Eff. Mursi, while plane-tabling here yesterday about 200 metres from camp reported that his pencil hissed whenever he put it in a vertical direction, but not in others. One of his instruments emitted a spark. There was thunder and lightning at the time.

2. At 1h.30m. today my wife woke me to show me St. Elmo's fire. She was sleeping in a small bivouac tent with two little poles. Each of these was crowned by a small flame, and everything in the tent fizzed and crackled. She received several small shocks. This stopped after five minutes and she went to bed, but shortly after saw two 'corposants' or balls of fire about the diameter of a five piastre piece (an inch). One ran up a rope and the other floated in the air.

I have often read of these phenomena, but this is the first time I have come across them in thirty years of desert surveying in Egypt.

Yours sincerely,
G. W. Murray."

In this connexion the following incident, reported by Dr. J. Ball and published in *Survey Notes*, Cairo, Vol. I, 1906, is of interest:

"I have just experienced a rather remarkable manifestation of atmospheric electricity whilst occupying the summit of Gebel Dahanib (altitude, 1,270 metres; 30 kilometres inland from Foul Bay, Red Sea) as a trigonometrical station.

About 10.30 a.m. on February 13th, I was observing in cloudy weather, with clouds drifting eastwards not far overhead. On approaching my eye to the eye-piece of the theodolite I received an electric spark above the eye from the instrument. At the same time a rapid succession of sparks about a centimetre long passed between my hand and the tangent screw of the horizontal circle. Before I had time to realise that was happening the whole instrument began to hiss and crackle. Simultaneously my head began to do the same, and I felt a prickly sensation all over it; the men who were with me remarked that my hair stood up stiffly like bristles. My sai was standing near, wearing a headcloth with long fringe, and I noticed that the threads of the fringe stood out stiffly, pointing upwards. A rather dense cloud was passing over at the time, and a few drops of rain fell. I at once ordered a general retreat from the immediate summit, fearing something stronger than I had just witnessed. My assistant endeavoured before descending to close the cap of the theodolite objective, but he received an electric shock in his arm which prevented further attempts.

I remarked in descending that as I clutched the rocks for support (the mountain face is exceedingly rough and steep) sparks passed between my hands and the rock. We remained away from the summit till the cloud had passed well over. On re-approaching the instrument twenty minutes later I found it uncharged.

The phenomena were evidently due to induction from a highly electrified cloud. The theodolite had a dry wooden tripod. I was wearing ordinary boots with nails in the sole. I stand slightly higher than the instrument. The hissing and crackling of both instrument and my hair seemed to show that both of us were acting as discharge points, and that the difference of potential between us was due to unequal efficiency as dischargers.

I may add that there was no sign of lightning or anything to indicate a special electrical condition of the air until I felt the spark, and nothing further was noticed beyond what I have stated. While no one would think of remaining on a high peak during a thunderstorm, the experience would tend to show that caution is advisable at mountain stations in cloudy weather even when there is no sign of thunder or lightning. The potential gradient may evidently be many thousands of volts per metre without a disruptive discharge, but when one takes sparks a centimetre or more long from one's theodolite one is inclined to wonder how much the conditions would need to be intensified for a lightning-stroke to occur and put a finish to one's geometrical activities."

L. J. SUTTON.

A Remark on " Divergent Winds "

In reading through the leading article in the December number of the *Meteorological Magazine* I was struck by the sentence : " The characteristic of this type of distribution is that the isobars, running fairly parallel from west to east over the western Atlantic open out over southern England, giving divergent winds and very pleasant weather ". It is natural for anyone familiar with the elements of dynamical meteorology immediately to connect divergence with subsidence and fair weather, so that it is fair to assume that the writer of the article implied a causal connexion between the winds and the weather. Whether or not such a connexion was intended, it is to be observed that " divergent ", according to the context, signifies merely a spreading out of the isobars, a very different matter from " divergence " as understood dynamically. It is a well-known fact that if the winds are everywhere geostrophic there is, very rigorously, no divergence or convergence however the isobars may run—the isobars may be regarded as defining tubes of flow through which the air moves, faster where the tube is narrow, more slowly where the tube is wide but, as in the case of the flow of water through a pipe of variable bore, with no accumulation or loss anywhere.

The winds are of course never more than approximately geostrophic and it is the departure from the geostrophic value which determines all divergence. The effect of spreading isobars upon the " geostrophic departure " is not difficult to determine with certain approximations, but theory does not suggest that the effect is such as to produce simple divergence. (It tends rather to produce divergence on the low pressure side balanced by convergence on the high pressure side due to an outflow across the isobars from low to high, other causes of divergence being ignored.)

In view of this fact there seems no obvious physical justification for the simple association of " divergent winds " with " pleasant weather ". Even if experience were to suggest such an association it would I think, without being pedantic, be desirable to avoid the use of the word " divergent " in this connexion if confusion is to be avoided.

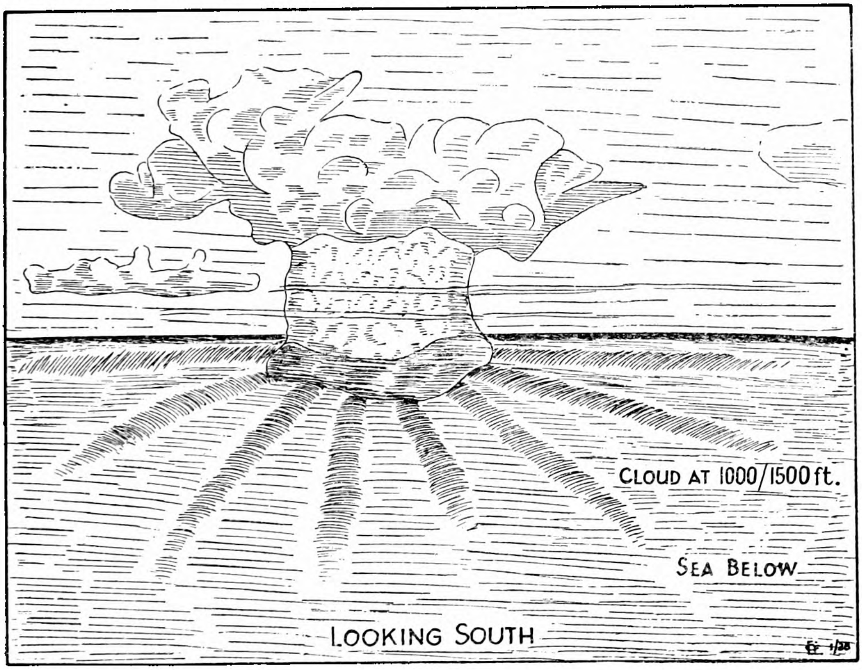
The article referred to was a discussion of average pressures and weather over a period of months and one is interested to learn that the summarized climatic data broadcast monthly are being charted regularly in the Meteorological Office. How one longs to see the charts studied critically and regularly in the manner of synoptic charts ! Is there not scope for the classification of different types with an attempt at discovering some sort of connexion between pressure and weather somewhat similar perhaps to the old empirical rules of the early days of forecasting ? But perhaps this work is already in hand and we may hope to see further discussions in the Magazine. The problem of seasonal forecasting is always at the back of one's mind and here we have at any rate a possible mode of attack.

R. C. SUTCLIFFE.

[Whatever the explanation, a pressure distribution of the type shown in Fig. 1 of the *Meteorological Magazine* for December, 1937, p. 254, does appear to be definitely associated with fine summer weather in England. The same type occurred in connexion with the droughts of 1887 and 1921, as illustrated in the *Quarterly Journal* of the Royal Meteorological Society, Vol. 48, 1922, p. 158, and on p. 167 of the same issue Mr. Carle Salter referred to the association as being well known. He used the term " fanning out " of the winds however, instead of divergence. The same type reappeared in the drought of 1933 and was illustrated in the *Quarterly Journal* for 1934, p. 51.—Ed. *M.M.*]

Curious cloud formation

We are indebted to Sergeant Winton, of the Royal Air Force Station, Boscombe Down, Wiltshire, for the accompanying sketch of a curious cloud formation observed from the air off the South Devon coast on November 1st, 1937. Mr. C. V. Ockenden, Meteorological Officer at Boscombe Down, supplies the following particulars :— "A shallow depression was centred in the western English Channel. Conditions were mainly fair in the west, but much low cloud and rain were encountered on the return journey eastward of Yeovil. It is not improbable that the large cumulus up to 9,000 ft. was quite close to the centre of the depression. The pilot was flying at 10,000 ft., and he estimates his distance from the towering cloud to be 12 to 15 miles."



The main body of the cloud with its anvil-like development is typical of a large cumulus cloud, but the radiating bands extending horizontally from the cloud base are remarkable. A continuous layer of low cloud was observed farther east and it is reasonable to suppose that the air at this level was almost saturated, and so required little upward motion to produce condensation. One is tempted to visualize a wave motion circulating round the cloud base although it is doubtful whether such an explanation would be dynamically acceptable. Judging from the diagram the bands might, however, be regarded as radiating from a point on the horizon rather than from the cloud base, in which case they would be parallel. The formation might therefore have to be explained as merely an illusion of perspective.

Rainfall in North and North-West Spain

A correspondent to the Editor of the *Meteorological Magazine* has drawn attention to reports of bad weather experienced by the opposing forces engaged in the Spanish civil war, particularly in the Bilbao sector, where Gen. Franco's forces were impeded by rain, wind and mist right up to the end of June. His impression appears to be that by the end of June, the weather in Spain should be fairly dry and quiet, unless the northern area differs from the remainder of the Iberian Peninsula. Alternatively, he suggests that conditions for 1937 are abnormal.

Unfortunately, regular reports are no longer received from Spain so that it is not possible to determine if conditions were abnormal last year, but an examination of rainfall averages indicates that there is definitely a considerable difference between the weather along the northern coast and that of the interior.

The prevailing NW. wind in advance of the Azores anticyclone brings most of the bad weather to northern Spain, and rain is deposited in large amounts (comparable with the rainfall of the west coast of Ireland) on the coastal slopes of the Cantabrian Mountains. Immediately to the south of this range there is a marked decrease followed by a steady decline southwards to the interior. In order to illustrate this, a table of averages is included for selected places ranging from the north coast of Spain to the interior at Madrid. The selected places are Santander, Bilbao and San Sebastien on the northern coast; Vitoria (30 miles inland from Bilbao); Burgos, to the south of the Cantabrian range; Valladolid and Salamanca on the plateau between the Cantabrian Mountains and the Sierra de Guarderrama; and, finally, Madrid, to the south of the Sierra de Guarderrama.

The variations of rainfall are clearly indicated by this table, and the following interesting points are observed :—

(*a*) The large falls along the coast compared with the interior.

(*b*) The exceptional total for San Sebastien. This is probably due to the westerly exposure of the station rather than to the height which is only 75 ft. above mean sea level.

(*c*) The driest months at San Sebastien are wetter than any month of the year at any station in the interior with the exception of Vitoria in May.

(*d*) At Vitoria, which is only 30 miles inland, the annual total is approximately half of that of the coast.

(*e*) At Madrid, the total fall is approximately one-third of that of the coast.

	Santander.	Bilbao.	San Sebastien.	Vitoria.	Burgos.	Valladolid.	Salamanca.	Madrid.
	in.	in.	in.	in.	in.	in.	in.	in.
January ...	4·6	4·3	6·5	2·6	0·9	0·9	1·0	1·3
February ...	3·5	3·7	4·5	2·8	1·9	2·0	1·9	1·3
March ...	3·7	4·4	4·8	2·8	2·4	2·2	2·4	1·6
April... ...	3·4	3·9	3·0	2·4	1·4	1·4	1·0	1·7
May	2·7	3·2	5·0	4·1	2·2	1·6	1·0	1·7
June ...	2·0	3·1	3·9	1·8	1·5	1·2	1·4	1·3
July	1·9	2·2	3·3	1·5	0·9	0·6	0·6	0·4
August ...	2·3	2·0	3·3	1·3	0·6	0·6	0·5	0·5
September ...	3·7	3·7	5·4	2·0	1·3	1·2	0·9	1·5
October ...	6·6	4·9	5·6	3·1	2·2	2·0	1·6	1·8
November ...	7·0	5·1	6·7	3·2	2·8	3·2	2·6	2·0
December ...	5·3	5·1	5·5	3·2	2·4	1·9	1·9	1·6
Year ...	46·7	45·6	57·5	30·8	20·5	18·8	16·8	16·7

It should be pointed out that the averages included in the table (with the exception of Bilbao and Madrid) are only for the five years 1925 to 1929, and were extracted from the *Resumen de las Observaciones* of the Spanish Meteorological Service. They appear to be sufficient, however, to indicate that conditions last year were not necessarily abnormal in the Bilbao sector and that near the northern coast considerable rainfall may be expected up to the end of June.

E. L. CLINCH.

REVIEWS

Icing measurements on Mount Washington. By S. Pagliuca. J.aero.Sci., New York, 4, 1937, pp. 399–402.

In a recent paper* on ice formation as affecting aircraft it was suggested that the ideal place for the study of this problem would be at one of the mountain top observatories. An account of a series of tests on a metal model of an aeroplane wing during a rime-forming fog is given by the author whilst on a vist to Mount Washington (1915m.) on February 4th, 1936. The model was installed 5 metres above the ground and free to adjust itself to windward. Measurements of rate of deposit and density (weight of water per unit volume) of deposit were taken at frequent intervals, the latter being obtained by melting a known volume of ice. At the time of the tests the air supply was of polar maritime origin with temperature ranging from —9° C. to —15° C., specific humidity from 1·4 to 2·2 gm/Kg. and wind velocity from 50 to 150 Km./hr. As would be expected at fairly low temperatures the deposit was slight, 0·4 to 1·7 cm./hr., the description being hard rime in nearly all tests. This was found to have a similar density to that of ordinary ice, but two samples of soft rime had considerably lower densities. Tests were also made on two vertical rods of different diameters and it is evident from the results that the rate of deposit, as well as the average density, varied considerably with the exposure and shape of the test object. The wind distribution was the chief factor and three very interesting photographs are included in the paper showing the increasing length of rime formation with height above ground, a direct result of increasing velocity with height. Rime-forming fogs are very frequent on Mount Washington and it is to be hoped that the results of further tests will be published, including if possible, data concerning the size and number of supercooled water drops concerned in the production of the ice deposits.

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* *London, Prof. Notes, met. Off.*, 6, No. 81, 1937.

W. H. Bigg.

The Climate of the Netherlands. E. Evaporation. By Dr. C. Braak. K. Ned. Meteor. Inst., No. 102, Med. en Verh. 39, pp. 34 (Dutch) + 16 (English summary). *Illus.*, 's-Gravenhage, 1936.

This memoir on evaporation forms the fifth part of an official publication on the climate of the Netherlands. The first two parts, A and B, dealing with rainfall and temperature appeared as long ago as 1913 and 1918 under the authorship of C. M. A. Hartman. The later volumes are by Dr. C. Braak. Of these, C. Pressure and D. Wind appeared together in 1929. In 1930 additional information was published about temperature and in 1933–4 a revised edition of Part A, Rainfall.

The text of the volumes is in Dutch but there is a very full English summary, amounting almost to a translation, and the headings of the tables are given in both languages.

The paper is divided into four parts. The first deals with observations from water surfaces. The standard observations are those made at De Bilt since 1909 using a balance and a shallow brass reservoir with a surface of 400 sq. cm. which is protected against strong winds and radiation from the sides by a white metal cylinder. The average annual evaporation from these measurements is 825 mm., the monthly averages varying from 15 mm. in December to 133 mm. in June and July. With these figures the data at some 16 stations in various parts of the Netherlands are compared, and it is pointed out that the differences in the results are due more to differences in the types of instruments and their exposure than to true differences in climate.

In the second part a short account is given of other observations than those of free water surfaces.

The third part discusses the annual and diurnal variation of evaporation at De Bilt and Den Helder and on the isle of Schokland in the Yssel-lake (the former Zuider Zee). Incidentally, the difficulties which arise from the introduction of " summer time " are illustrated by the fact that, in discussing the diurnal variation, data for the later years have had to be omitted on account of a shift in the time of observation during part of the year.

The paper concludes with a calculation of the constants in the well-known formula connecting evaporation with temperature, wind-velocity and difference of vapour pressure from saturation.

BOOKS RECEIVED

A study of correlation coefficients of mean maximum temperatures between successive months at a few selected stations in India. By R. J. Kalamkar, Ph.D. India, Meteor. Dept., Sci. Notes, Vol. VII, 1936, No. 70.

Ergebnisse Aerologischer Beobachtungen, 24, 1935. K. Ned. Meteor. Inst. (No. 106A) Utrecht, 1936.

OBITUARY

We regret to learn of the death of Dr. G. E. Hale, one of the founders of Yerkes and Mount Wilson Observatories, on February 22nd, at Pasadena, California.

NEWS IN BRIEF

A gold medal has been awarded to the Director of the Meteorological Office by the Committee of the 1937 International Exhibition in Paris for the exhibit of apparatus used in the Meteorological Office for the exploration of the upper atmosphere.

On February 28th, 1938, Prof. E. van Everdingen retired from his position as Director of the Koninklijk Nederlandsch Meteorologisch Instituut. He is succeeded by Dr. H. G. Cannegieter.

Prof. Dr. H. v. Ficker, Director of the Austrian Zentralanstalt für Meteorologie und Geodynamik, in succession to Dr. W. Schmidt, has been awarded the Hellmann Silver Medal, and has been elected an honorary member of the German Meteorological Society.

A branch of the German Meteorological Society has been founded at Frankfurt a.M., incorporating the Frankfurt Forschungsinstitut and the Rhine-Main section of the Reichswetterdienst. The President is Prof. Dr. F. Linke, Vice-President: Dr. F. Baur.

We learn that Prof. M. N. Saha of the Allahabad University has been elected President of the National Institute of Sciences of India.

The seventeenth Annual Dinner of the Meteorological Office staff, Shoeburyness, was held at the Palace Hotel, Southend-on-Sea, on Saturday, February 12th. The guests of the staff were Mr. J. S. Dines, M.A., Superintendent for Army Services, and Col. F. N. C. Rossiter, R.A., the Superintendent of Experiments, Shoeburyness. After the dinner an excellent entertainment was given by members of the staff.

The Weather of February, 1938

Pressure was very high over central and southern Europe, exceeding 1020 mb. from lat. 57° N. to the Mediterranean and 1025 mb. over southern Ireland, southern England, most of France, Switzerland, Austria and Czechoslovakia. An area of low pressure (below 1005 mb.) extended from south of Greenland across Jan Mayen to the Barents Sea, falling below 1000 mb. over Spitsbergen and Bear Is. A tongue of low pressure extended southwards in mid-Atlantic to 40° N. Pressure was above 1025 mb. in the Siberian anticyclone, which extended nearly to the Arctic coast of east Siberia, and as in January there was a steep gradient for southerly winds in the Kara Sea. Pressure was also above 1025 mb. over most of Canada, falling to below 1010 mb. in the north Pacific. Pressure was 10 mb. or more above normal over the British Isles, the Faeroes and Iceland, and also in central Canada and Alaska. The Barents Sea was 10 mb. below normal and the Azores 5 mb. below.

Weather was again abnormally warm in many parts of the Arctic. The strong south-westerly winds were reflected in a tongue of high temperature extending across Scandinavia and the Barents Sea to the north of Novaya Zemlya; northern Sweden (25°–30° F.) and Spitsbergen (19° F.) were more than 10° F. above normal. The British Isles with averages of 40°–45° F. were slightly above normal, as was central Europe, while in Turkestan and southern Siberia the excess was more than 5° F. The " cold pole " however, with —35° F. at Jakutsk, was 3° F. colder than usual. The United States was abnormally warm, temperatures of 50° F. south of Chicago representing an excess of 9° F., but north-east Canada was very cold, the figure of —21° F. at Dawson being 10° F. below normal.

Precipitation was generally scanty over the whole of Europe except for local marked excesses of 4 in. at Malta and Athens. Northern Asia was also dry on the whole. North America was dry except for local areas of heavy rains north-west of the Great Lakes (Minnedosa nearly 4 in.), and on the Pacific coast of the United States, where disastrous floods occurred. At San Francisco the rainfall for the month was 9 in. or 6 in. above normal.

Over Australia, the East Indies and the West Pacific pressure was below normal, especially in south-east Australia (Hobart—8 mb.). The low pressure area in the interior of Australia was more intense and extended further to the south-east than usual. New Zealand was normal. Temperature was several degrees below normal in central Australia but above normal in eastern Australia and New Zealand, the excess being more than 5° F. at Brisbane and over most of New Zealand. Rainfall was very heavy in the north-east of West Australia, the Northern Territories, South Australia and northern Queensland, exceeding 6 in. in many districts, and 12 in. locally; rainfall was also much above normal in most of New Zealand.

The earlier part of the month was stormy and mild, but depressions moving south-east in the middle of the month brought arctic air to the British Isles. The cold spell was accompanied by northerly gales in the North Sea, and as this period corresponded with spring tides considerable damage was done in eastern coastal districts. Quieter anticyclonic conditions with night fog and frost followed, but the mild stormy weather returned at the close of the month. Rainfall was generally scanty, some areas receiving only 23–30 per cent of the normal. Sunshine was slightly below average in the Midlands, but elsewhere about normal. An intense depression centred to the north of Scotland brought widespread westerly gales on the 1st, gusts of 85 m.p.h. and 82 m.p.h. being recorded at the Lizard and Pembroke respectively; rain and hail fell in most districts. Temperatures rose generally from the 2nd–4th and winds remained high reaching gale force again on the 3rd and 4th. There was little rain but considerable sunshine, the Channel Islands recording 6–8 hrs. on the 5th, and Scotland and Ireland on the 6th. Aurora was observed in north Scotland on the 1st, 5th, 6th and 8th. Fog was reported locally from the 6th to 9th. Minimum temperatures were low in Scotland on the 7th. The 9th to 13th saw a return to squally conditions, and gales were reported every day. Rain fell heavily on the 9th, 1·37 in. being recorded at Blaenau Festiniog, Merionethshire. Snow and hail fell in Scotland and the north on the 10th; temperatures were high in England, screen minima of 49° F. being recorded at Ross-on-Wye and Falmouth, and thunderstorms were reported from Kew and Whitstable. Complex depressions moving south-east from the Baltic on the 11th and 12th brought colder weather and northerly gales. An anticyclone spread eastwards from Ireland, and centred over Scotland on the 14th. Temperatures were generally low, maxima of 35° F. being recorded generally in the south on the 14th–16th. In Scotland Dalwhinnie had a screen minimum of 17° F. on the 16th, with grass minimum of 8° F. Snow and hail fell locally in all districts except north Scotland from the 11th–17th, being particularly severe in the south-east of England where drifts up to 8 ft. were formed. There was considerable sunshine over the whole country except the Channel Islands on most days, Oban recording 9·1 hrs. on the 17th and 8·7 hrs. on the 18th; Hastings 9·0 hrs. on the 19th and Plymouth 9·1 hrs. on the 20th. Temperature rose generally on the 18th and 19th, but fell in the south on the 22nd, when maxima of 35° F. were again reported. Snow fell in Dublin on the 21st and 22nd. Good sunshine records were obtained in the Channel Isles on the 20th–24th, in England on the 23rd—over 9 hrs. at several places in the south—and generally on the 24th. A depression extending from Greenland to the Azores moved eastwards on the 24th and brought rain to Ireland. Temperature rose rapidly on the 25th and 26th when Nottingham had a maximum of 60° F. on the 25th, and Dublin on the 25th and 26th. The maximum of 59° F. at Ross-on-Wye on the 25th was the highest since 1921. Rain fell generally on the 25th and 26th, the heaviest falls being 1·44 in. at Rhayader and 1·27 in. at Ponterwyd, Cardigan, on the 26th. Fog was reported daily in south Scotland, north and east England from the 20th–26th. Deep depressions crossing the country brought renewed southerly gales to the north, west and south coasts on the 26th–28th. The distribution of bright sunshine for the month was as follows :—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ..	52	− 3	Chester ..	56	− 6
Aberdeen ..	62	− 8	Ross-on-Wye	54	−15
Dublin	53	−22	Falmouth ..	70	−10
Birr Castle ..	69	+ 3	Gorleston ..	83	+ 8
Valentia ..	71	+ 5	Kew.. ..	70	+ 9

Kew, Temperature, Mean, 40·1, Diff. from average — 1·2.

Miscellaneous notes on weather abroad culled from various sources. After several days of sunny weather snow fell in Switzerland on the 9th down to the 3,000 ft. level—ski-ing conditions improved and remained good throughout the month. Gales were reported from the North Sea on the 10th, and on the 11th and 14th from the north Mediterranean coasts, where shipping was delayed and air services from Marignane suspended. Rain fell on the Riviera on the 16th breaking the drought which, with bright sunshine, has prevailed since December. Heavy rain and snow caused flooding in the Naples district on the 17th. (*The Times*, February 11th–18th.)

Floods followed heavy rain near Smyrna on the 5th, much property was damaged and 13 villages isolated. A series of blizzards over South Sakhalin from the 17th–20th caused avalanches which destroyed many houses and killed 116 people. (*The Times,* February 5th–21st.)

Torrential monsoon rains fell in Northern Territory and Central and South Australia during February, and the extensive floods resulted in the breakdown of railway and telegraphic communication, but opened up arid land for grazing. Adelaide experienced the wettest February since records began 100 years ago. A cloudburst in Hawkes Bay, New Zealand caused a torrent to overwhelm a camp and 21 people were drowned. (*The Times*, February 21st-28th.)

A sharp thaw and rain in Ontario on the 5th, followed by a keen frost gave icy roads and all traffic was suspended. Floods were reported from Wisconsin on the 5th and 6th and from the Mohawk River region of New York State, and the Canadian Thames on the 7th. Violent gales on the Californian coast on the 9th caused the death of six people and much damage to trees and property. A blizzard swept across the Prairie Provinces of Canada on the 13th–14th. After a month of northerly winds the north-east coast of Newfoundland was reported to be completely blocked by ice on the 25th and all navigation ceased. A blizzard in Ontario on the 28th was accompanied by a sharp drop in temperature, the fall being as much as 30° F. in a few hours at some places. (*The Times*, February 8th–March 1st.)

Daily Readings at Kew Observatory, February, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain.	Sun.	REMARKS (see vol. 69, 1934, p. 1).
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1000·3	SW.5	39	45	61	0·01	5·5	r_0 1h., pr_0 13h., 14h.
2	1014·9	W.4	38	48	69	—	1·1	pr_0 15h., 17h.
3	1027·3	SW.3	41	54	74	—	1·3	
4	1031·5	SW.4	42	52	63	—	0·7	
5	1024·4	SSW.3	41	51	64	—	4·8	
6	1029·6	WSW.1	35	49	73	—	0·1	x early, f 9h.–13h.
7	1029·2	NE.4	40	46	73	—	0·0	f 9h., m 15h.
8	1023·7	SSE.1	41	45	77	—	0·1	
9	1021·5	SW.4	40	48	72	Trace	3·3	r_0 13h., 14h.–15h.
10	1015·9	NNW.5	45	53	83	0·06	1·5	ir_0–r 11h.–13h. R 12h.
11	1036·0	NNW.3	34	43	50	—	6·8	
12	1017·8	NW.5	35	50	50	—	5·3	pr_0 15h., 23h.
13	1024·1	NNE.5	35	41	64	—	3·6	r_0 6h., is_0 19h.–20h.
14	1025·2	NE.4	32	36	72	Trace	3·6	is_0 7h.–9h., 13h., 21h.
15	1024·3	NE.5	32	37	62	—	0·0	is_0 most of day.
16	1025·5	NE.4	34	36	82	0·01	0·0	ir_0 6h.–18h., s_0 9h.
17	1022·5	ENE.4	35	38	87	0·08	0·0	r_0s_0–s 11h.–16h.
18	1026·8	NE.5	31	50	54	—	6·0	x early.
19	1031·3	NE.4	36	44	77	—	4·1	
20	1035·5	NNE.4	33	43	78	—	1·6	x early.
21	1032·3	NE.3	38	40	77	—	0·0	m 8h.–16h.
22	1027·5	NE.2	34	37	72	—	0·0	m 21h., f 22h.–24h.
23	1027·9	E.3	33	44	63	—	4·2	fx early, m till 10h.
24	1027·2	SE.2	32	46	67	—	6·3	fx till 10h., x late.
25	1024·1	SSE.3	28	56	63	—	1·8	Fx–fx till 10h.
26	1017·9	S.3	47	55	71	0·12	1·8	r_0–r 7h.–9h., 18h.–20h
27	1027·8	W.5	42	50	48	0·02	6·4	ir_0 17h.–23h.
28	1024·0	SSW.5	45	53	78	0·01	0·0	r–r_0 24h.
*	1024·9	—	37	46	69	0·31	2·5	* Means or Totals.

General Rainfall for February, 1938

England and Wales	52	per cent of the average 1881–1915.
Scotland	80	
Ireland	66	
British Isles ...	62	

Rainfall : February, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
Lond	Camden Square..........	·48	29	*Leics*	Thornton Reservoir ...	·90	54
Sur	Reigate, Wray Pk. Rd..	·89	41	,,	Belvoir Castle............	·87	52
Kent	Tenterden, Ashenden...	1·07	54	*Rut*	Ridlington	·99	60
,,	Folkestone, Boro. San.	1·35	...	*Lincs*	Boston, Skirbeck.........	·87	60
,,	Margate, Cliftonville....	·64	46	,,	Cranwell Aerodrome...	1·44	96
,,	Eden'bdg., Falconhurst	1·24	56	,,	Skegness, Marine Gdns.	·56	37
Sus	Compton, Compton Ho.	·54	20	,,	Louth, Westgate.........	·92	48
,,	Patching Farm..........	·86	39	,,	Brigg, Wrawby St.......	1·19	...
,,	Eastbourne, Wil. Sq....	·97	44	*Notts*	Mansfield, Carr Bank...	·59	31
Hants.	Ventnor, Roy.Nat.Hos.	1·08	51	*Derby*	Derby, The Arboretum	·61	36
,,	Southampton,East Park	·68	30	,,	Buxton, Terrace Slopes	2·49	66
,,	Ovington Rectory.......	·73	28	*Ches*	Bidston Obsy.............	·43	26
,,	Sherborne St. John......	·51	23	*Lancs.*	Manchester, Whit. Pk.	1·07	56
Herts	Royston,Therfield Rec.	·40	26	,,	Stonyhurst College......	2·11	63
Bucks.	Slough, Upton............	·35	21	,,	Southport, Bedford Pk.	1·09	52
Oxf	Oxford, Radcliffe.........	·83	51	,,	Ulverston, Poaka Beck	1·71	46
N'hant	Wellingboro, Swanspool	·80	50	,,	Lancaster, Greg Obsy.	1·55	54
,,	Oundle	·61	...	,,	Blackpool	1·13	50
Beds	Woburn, Exptl. Farm...	·63	43	*Yorks.*	Wath-upon-Dearne......	1·09	66
Cam	Cambridge, Bot. Gdns.	·44	34	,,	Wakefield,Clarence Pk.	·81	47
,,	March......................	·75	58	,,	Oughtershaw Hall.......	4·51	...
Essex	Chelmsford,County Gdns	·47	32	,,	Wetherby, Ribston H..	1·97	114
,,	Lexden Hill House......	·49	...	,,	Hull, Pearson Park......	·90	54
Suff	Haughley House.........	·78	...	,,	Holme-on-Spalding......	1·27	76
,,	Rendlesham Hall........	·71	51	,,	Felixkirk, Mt. St. John.	2·16	128
,,	Lowestoft Sec. School...	·76	54	,,	York, Museum Gdns....	1·26	83
,,	Bury St. Ed., WestleyH.	·97	65	,,	Pickering, Houndgate...	1·20	69
Norf.	Wells, Holkham Hall...	·85	57	,,	Scarborough..............	·98	58
Wilts	Porton, W.D. Exp'l. Stn	·60	30	,,	Middlesbrough...........	1·40	108
,,	Bishops Cannings........	1·14	54	,,	Baldersdale, Hury Res.	1·67	55
Dor	Weymouth, Westham.	·69	32	*Durh*	Ushaw College...........	1·34	84
,,	Beaminster, East St....	1·48	49	*Nor*	Newcastle, Leazes Pk...	·98	64
,,	Shaftesbury,Abbey Ho.	·78	34	,,	Bellingham, Highgreen	1·34	53
Devon.	Plymouth, The Hoe....	1·29	43	,,	Lilburn Tower Gdns....	1·24	62
,,	Holne, Church Pk. Cott.	3·35	61	*Cumb.*	Carlisle, Scaleby Hall...	1·08	48
,,	Teignmouth, Den Gdns.	·89	33	,,	Borrowdale, Seathwaite	6·75	60
,,	Cullompton	1·28	46	,,	Thirlmere, Dale Head H.	5·26	69
,,	Sidmouth, U.D.C........	·82	...	,,	Keswick, High Hill......	2·37	48
,,	Barnstaple, N. Dev.Ath	1·20	44	,,	Ravenglass, The Grove	1·57	51
,,	Dartm'r,Cranmere Pool	4·90	...	*West*	Appleby, Castle Bank...	1·29	44
,,	Okehampton, Uplands.	1·92	44	*Mon*	Abergavenny, Larchf'd	1·03	32
Corn	Redruth, Trewirgie......	2·27	60	*Glam*	Ystalyfera, Wern Ho....	4·14	81
,,	Penzance, Morrab Gdns.	2·11	63	,,	Treherbert, Tynywaun.	5·41	...
,,	St. Austell, Trevarna...	2·31	60	,,	Cardiff, Penylan..........	1·83	62
Soms	Chewton Mendip.........	1·77	53	*Carm*	Carmarthen,M. & P. Sch.	2·29	59
,,	Long Ashton............	1·11	47	*Pemb*	Pembroke,Stackpole Ct.	1·64	59
,,	Street, Millfield..........	·84	43	*Card*	Aberystwyth	1·57	...
Glos	Blockley	·83	...	*Rad*	BirmW.W.Tyrmynydd	3·77	72
,,	Cirencester, Gwynfa....	·98	43	*Mont*	Newtown, Penarth Weir	1·36	54
Here	Ross-on-Wye..............	·69	34	,,	Lake Vyrnwy	3·37	74
Salop	Church Stretton.........	·88	40	*Flint*	Sealand Aerodrome......	·48	31
,,	Shifnal, Hatton Grange	·37	23	*Mer*	Blaenau Festiniog	5·78	78
,,	Cheswardine Hall........	·73	41	,,	Dolgelley, Bontddu......	3·32	57
Worc	Malvern, Free Library...	·66	37	*Carn*	Llandudno	·47	24
,,	Ombersley, Holt Lock.	·48	29	,,	Snowdon, L. Llydaw 9..	10·65	...
War	Alcester, Ragley Hall...	·55	33	*Ang*	Holyhead, Salt Island...	·92	38
,,	Birminghm, Edgbaston	·89	53	,,	Lligwy	1·17	...

Rainfall : February, 1938 : Scotland and Ireland

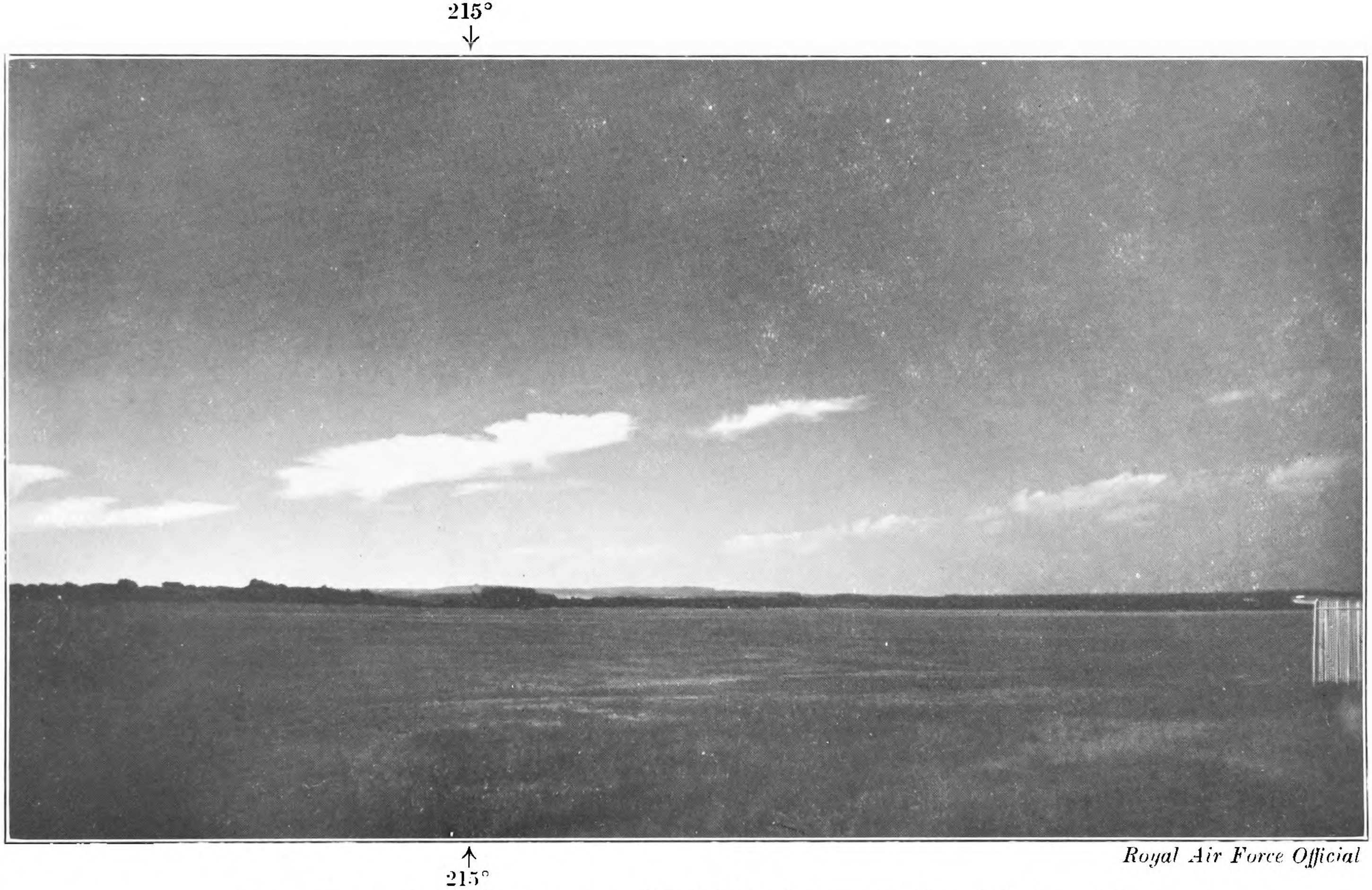
Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	1·62	51	*R&C* .	Achnashellach	7·83	108
Guern.	St.Peter P't.Grange Rd.	1·65	67	,, .	Stornoway,C.GuardStn.	3·56	84
Wig .	Pt. William, Monreith.	2·04	66	*Suth* .	Lairg........................	3·20	103
,, .	New Luce School.........	2·94	77	,, .	Skerray Borgie...........	4·04	...
Kirk .	Dalry, Glendarroch......	3·92	77	,, .	Melvich......................	2·56	86
Dumf.	Dumfries, Crichton R.I.	1·99	65	,, .	Loch More, Achfary....	8·32	126
,, .	Eskdalemuir Obs........	4·48	91	*Caith* .	Wick.........................	2·05	90
Roxb .	Hawick, Wolfelee........	1·58	48	*Ork* .	Deerness	2·82	94
Peeb .	Stobo Castle..............	1·26	46	*Shet* .	Lerwick Observatory...	2·40	76
Berw .	Marchmont House......	·85	41	*Cork* .	Cork, University Coll...	3·11	83
E.Lot .	North Berwick Res.....	·46	30	,, .	Roches Point, C.G. Stn.	2·38	64
Midl .	Edinburgh, Blackfd. H.	·58	35	,, .	Mallow, Longueville....	3·42	101
Lan .	Auchtyfardle	1·49	...	*Kerry*.	Valentia Observatory...	3·59	69
Ayr .	Kilmarnock, Kay Park	1·73	...	,, .	Gearhameen...............	9·50	107
,, .	Girvan, Pinmore.........	2·75	64	,, .	Bally McElligott Rec...	2·72	...
,, .	Glen Afton, Ayr San. ...	3·68	84	,, .	Darrynane Abbey.......	2·94	63
Renf .	Glasgow, Queen's Park	2·10	71	*Wat* .	Waterford, Gortmore...	2·30	71
,, .	Greenock, Prospect H..	4·33	82	*Tip* .	Nenagh, Castle Lough.	1·72	55
Bute .	Rothesay, Ardencraig...	3·06	77	,, .	Cashel, Ballinamona....	2·28	72
,, .	Dougarie Lodge..........	1·99	53	*Lim* .	Foynes, Coolnanes......	1·61	50
Arg .	Loch Sunart, G'dale....	7·49	125	*Clare* .	Inagh, Mount Callan....	2·91	...
,, .	Ardgour House..........	15·00	...	*Wexf* .	Gorey, Courtown Ho...	1·59	57
,, .	Glen Etive..................	...	...	*Wick* .	Rathnew, Clonmannon.	1·17	...
,, .	Oban........................	4·98	...	*Carl* .	Bagnalstown,Fenagh H.	2·16	85
,, .	Poltalloch..................	4·35	101	,, .	Hacketstown Rectory...	1·78	59
,, .	Inveraray Castle.........	12·62	186	*Leix* .	Blandsfort House.......	1·90	71
,, .	Islay, Eallabus............	3·39	81	*Offaly*.	Birr Castle................	1·44	63
,, .	Mull, Benmore............	14·60	131	*Kild* .	Straffan House...........	1·17	54
,, .	Tiree	3·26	95	*Dublin*	Dublin, Phoenix Park..	·59	33
Kinr .	Loch Leven Sluice.......	·95	34	,, .	Balbriggan, Ardgillan...	...	...
Fife .	Leuchars Aerodrome...	·47	27	*Meath*.	Kells, Headfort..........	1·55	57
Perth .	Loch Dhu..................	9·25	124	*W.M* .	Moate, Coolatore.........	1·38	...
,, .	Crieff, Strathearn Hyd.	2·48	70	,, .	Mullingar, Belvedere...	1·66	60
,, .	Blair Castle Gardens....	1·97	71	*Long* .	Castle Forbes Gdns......	2·08	73
Angus.	Kettins School............	·67	29	*Gal* .	Galway, Grammar Sch.	·96	32
,, .	Pearsie House............	1·17	...	,, .	Ballynahinch Castle....	4·62	90
,, .	Montrose, Sunnyside...	·84	46	,, .	Ahascragh, Clonbrock.	2·32	75
Aber .	Balmoral Castle Gdns..	1·36	52	*Rosc* .	Strokestown, C'node.....	1·91	72
,, .	Logie Coldstone Sch....	1·24	60	*Mayo*.	Blacksod Point..........	3·07	76
,, .	Aberdeen Observatory.	1·03	50	,, .	Mallaranny	4·21	...
,, .	New Deer School House	1·42	67	,, .	Westport House.........	2·16	55
Moray	Gordon Castle............	1·40	73	,, .	Delphi Lodge.............	8·25	98
,, .	Grantown-on-Spey	2·13	100	*Sligo* .	Markree Castle...........	2·48	71
Nairn.	Nairn	1·11	62	*Cavan*.	Crossdoney, Kevit Cas..	1·93	...
Inv's .	Ben Alder Lodge.........	7·06	...	*Ferm* .	Crom Castle...............	2·50	85
,, .	Kingussie, The Birches.	2·46	...	*Arm* .	Armagh Obsy............	1·19	54
,, .	Loch Ness, Foyers	...	...	*Down*.	Fofanny Reservoir......	4·02	...
,, .	Inverness, Culduthel R.	1·13	50	,, .	Seaforde	1·76	58
,, .	Loch Quoich, Loan......	19·63	...	,, .	Donaghadee, C. G. Stn.	1·20	52
,, .	Glenquoich.................	16·72	162	*Antr* .	Belfast,Queen's Univ....	1·21	49
,, .	Arisaig House............	5·08	102	,, .	Aldergrove Aerodrome.	1·05	44
,, .	Glenleven, Corrour......	9·03	137	,, .	Ballymena, Harryville.	2·01	62
,, .	Fort William, Glasdrum	12·86	...	*Lon* .	Garvagh, Moneydig....	2 65	...
,, .	Skye, Dunvegan.........	6·26	...	,, .	Londonderry, Creggan.	2·69	84
,, .	Barra, Skallary.........	3·06	...	*Tyr* .	Omagh, Edenfel.........	1·95	65
R&C.	Tain, Ardlarach..........	2·16	87	*Don* .	Malin Head...............	1·46	49
,,	Ullapool	4·37	102	,,	Dunkineely................	2·34	...

Climatological Table for the British Empire, September, 1937

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
	Mean of Day M.S.L.	Diff. from Normal.	Absolute.		Mean Values.				Mean.			Am'nt.	Diff. from Normal.	Days.	Hours per day.	Per-cent-age of possi-ble.
			Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.							
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1013·8	− 3·6	76	41	65·3	49·5	57·4	+ 0·1	51·1	91	7·1	2·04	+ 0·17	12	5·1	40
Gibraltar	1015·4	− 1·8	92	60	75·5	65·4	70·5	− 1·9	64·4	84	4·2	0·08	...	2	...	...
Malta	1015·5	− 0·8	88	63	80·1	70·5	75·3	− 0·7	70·6	80	4·7	2·15	+ 0·88	6	7·3	59
St. Helena	1015·5	− 0·5	64	52	59·6	53·9	56·7	+ 0·2	54·5	94	10·0	1·99	− 0·19	18	...	...
Freetown, Sierra Leone	1012·9	+ 2·4	86	68	82·9	72·1	77·5	...	74·5	87	7·5	25·08	− 3·40	26	...	...
Lagos, Nigeria	1013·2	+ 1·0	86	71	82·9	74·6	78·7	0·0	75·0	90	8·7	12·54	+ 6·95	19	3·8	31
Kaduna, Nigeria	1012·1	...	89	65	85·1	68·4	76·7	+ 1·4	70·9	88	8·3	8·56	− 2·94	19	6·2	51
Zomba, Nyasaland	1013·2	− 0·4	86	52	79·8	60·3	70·1	+ 0·6	66·5	77	2·9	0·00	− 0·34	...	...	...
Salisbury, Rhodesia	1013·7	− 0·9	87	43	79·9	53·9	66·9	+ 0·5	54·7	44	1·0	0·00	...	...	9·8	82
Cape Town	1021·0	+ 1·9	84	42	66·8	51·7	59·3	+ 1·4	53·1	83	5·5	1·69	− 0·55	9	...	...
Johannesburg	1016·1	+ 0·7	84	30	69·8	47·0	58·4	− 1·0	46·7	45	3·7	1·06	+ 0·10	6	8·6	72
Mauritius	1020·1	0·0	80	61	77·5	64·6	71·1	+ 1·0	67·1	74	5·3	1·83	+ 0·43	20	7·9	66
Calcutta, Alipore Obsy.	1004·5	0·0	93	75	89·0	79·1	84·1	+ 0·9	79·8	90	8·1	13·31	+ 3·30	15*	...	...
Bombay	1007·7	− 0·3	88	73	85·6	76·2	80·9	0·0	76·4	87	8·1	14·20	+ 3·52	19*	...	...
Madras	1006·9	+ 0·4	97	74	93·4	77·7	85·5	+ 0·3	76·3	73	6·4	4·00	− 0·85	7*	...	...
Colombo, Ceylon	1010·4	+ 0·5	88	73	85·9	76·3	81·1	− 0·1	76·5	74	6·9	14·97	+ 10·21	14	7·1	58
Singapore	1010·3	+ 0·5	88	73	85·3	76·6	80·9	− 0·2	77·2	81	7·3	7·95	+ 1·16	14	5·2	43
Hongkong	1010·2	+ 1·9	91	75	87·0	78·9	82·9	+ 1·9	78·3	79	6·3	12·53	+ 2·84	12	6·9	57
Sandakan	1009·8	...	92	73	88·7	75·3	82·0	+ 0·3	77·1	83	7·2	7·60	− 1·73	17	...	...
Sydney, N.S.W.	1016·5	+ 0·4	89	44	70·5	53·5	62·0	+ 2·8	54·8	54	4·5	0·49	− 2·37	5	8·1	68
Melbourne	1015·3	− 0·5	75	41	64·4	48·5	56·5	+ 2·4	51·2	66	6·3	1·70	− 0·74	15	4·3	37
Adelaide	1017·9	+ 0·4	81	42	66·8	49·5	58·1	+ 0·9	52·7	64	7·4	2·92	+ 0·84	14	5·4	46
Perth, W. Australia	1026·6	+ 8·6	80	39	66·3	49·4	57·9	− 0·3	53·0	63	5·0	2·69	− 0·73	12	7·9	67
Coolgardie	1019·0	+ 1·8	92	37	71·9	46·0	58·9	+ 0·2	49·9	55	3·7	0·19	− 0·48	4	...	...
Brisbane	1020·3	+ 2·7	87	46	76·6	55·5	66·1	+ 0·9	58·7	56	2·6	0·20	− 1·80	1	9·3	78
Hobart, Tasmania	1011·7	+ 0·7	74	36	59·6	44·9	52·3	+ 1·3	47·4	64	6·4	1·87	− 0·20	16	5·2	44
Wellington, N.Z.	1013·7	− 0·9	60	37	54·3	44·6	49·5	− 2·1	47·1	80	8·5	3·51	− 0·46	20	4·2	36
Suva, Fiji	1016·1	+ 1·8	85	64	78·5	69·2	73·9	− 0·6	68·3	75	6·8	6·95	− 0·74	16	4·5	38
Apia, Samoa	1012·6	+ 0·4	87	69	84·4	73·7	79·1	+ 0·9	74·5	73	4·8	5·46	+ 0·35	16	7·4	62
Kingston, Jamaica	1011·9	− 0·3	93	73	89·8	74·6	82·2	+ 0·7	72·7	82	2·7	1·88	− 2·15	4	8·8	72
Grenada, W.I.	1010·5	− 1·3	88	70	86	73	79·5	− 0·8	74	74	5	6·79	− 1·20	16	...	...
Toronto	1017·5	− 0·3	90	37	69·9	50·3	60·1	− 0·2	53·0	84	3·6	1·39	− 1·28	11	7·5	60
Winnipeg	1015·0	+ 1·2	87	26	64·8	42·6	53·7	0·0	43·8	89	6·4	2·29	+ 0·07	12	5·6	44
St. John, N.B.	1016·3	− 1·1	74	42	65·0	50·6	57·8	+ 1·9	53·3	84	6·3	5·97	+ 2·23	16	5·5	44
Victoria, B.C.	1017·1	+ 0·7	88	45	65·3	50·6	57·9	+ 1·8	54·6	83	5·3	0·38	− 1·43	6	6·6	52

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Frontispiece]



Royal Air Force Official

Cirrus Cloud, South Farnborough, 1000 G.M.T. September 29th, 1937 (*see* p. 73)

M.O. 422.

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English Meteorological Periodicities of the Order of a few Decades

By JOSEPH BAXENDELL

I understand that the periodic element in the variations of the annual temperature at Oxford from 1815, to which Miss L. F. Lewis has drawn attention in *Professional Notes* No. 77, as being strongly indicated in her Fig. 5, has occasioned some little surprise and disappointment amongst outside meteorologists, owing to its obvious length [of nearly 40 years] being so much greater than either that of the constantly quoted Brückner period of 35 years, or the frequently suggested shorter one of three times the sunspot cycle, and yet being considerably shorter than the now well-known 52± year periodicity. It may therefore be worth while to review briefly the present state of our knowledge of English meteorological periodicities or quasi-periodicities of the order of a few decades, or at least of the chief of them; the more so because some important implications of Miss Lewis's Fig. 6 appear to have escaped attention.

First place must, I think, be given to the above mentioned cycle of rather more than half a century, indicated so markedly in the late Mr. G. J. Symons's famous diagram of the "Variations of English [annual] Rainfall from 1726", that formed a folding frontispiece to *British Rainfall*, 1891. From an analysis of completely recalculated data (in which additional old records were incorporated), that Dr. J. Glasspoole prepared and published in 1928*, Dr. C. E. P. Brooks and he obtained, as the length of this periodicity,

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* *Met. Mag., London*, 63, 1928, p. 1.

51·7 years*. More recently, Dr. Brooks and Miss Hunt have found it in London wind-direction data, with a length of about 51 years†. Confirmation of the existence of such a meteorological cycle, and evidence of its persistence in the past, for a great many centuries, with a length of between 51 and 53 years, has come from various meteorologists and geologists in the western hemisphere. Also a quarter of a century ago, the late Professor H. H. Turner, F.R.S., stated that among the terms with material amplitudes, which he found from his analysis of sunspot data‡, was one of 52 years.

But before I first publicly mentioned§ this periodic variation of something over 50 years, the late Mr. F. Lees Halliwell, F.R. Met. S., formerly chief assistant at the Fernley Observatory, had helped me to re-calculate completely the annual rainfall values for Mr. Symons' diagram, adopting three suggestions that Symons had made, and one of my own; and on analysing this amended material by a method devised by my father, and later developed and much used by the late Professor Balfour Stewart, my cousin, Charles Baxendell found *two* apparently periodic terms of the order of a few decades, the lengths of which were, approximately, 53 years, and 38½ years. In the course of the analysis of Dr. Glasspoole's later revised English rainfall data, already mentioned, Dr. Brooks independently found also the second of these cycles; he considered its length to be perhaps not more than between 37 and 38 years, but certainly much in excess of Brückner's alleged 34·8 years. He had previously found it, with a length of over 39 years, in his elaborate analysis of Nile-flood data for some 800 years||. Some years before this latter work, however, in a communication¶ to the Royal Meteorological Society, Professor H. H. Turner gave his finally suggested length of the full cycle of his "weather chapters" as 38·8 years, and he had previously** shown, mathematically, that a period of over 38 years suited Brückner's own long list of "cold winters" decidedly better that the latter's 35 years. Turner also found confirmation of the not far from 40 year length of this period in much Greenwich data, in the long Padua rainfall record, and even in the mean sea level at Aberdeen. In the foregoing (and other) ways, Miss Lewis's periodicity of nearly 40 years has very considerable ulterior support; while older English temperature data (for London) reveal a most corroborative earlier maximum, 41 years before her first at Oxford.

We have frequently been told, during recent years, in meteorological books and periodicals, that Francis Bacon affirmed that "in the Low Countries" it was said to have been observed "that

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* C. E. P. Brooks and J. Glasspoole, British Floods and Droughts, p. 188.

† *Met. Mag., London,* 68, 1933, p. 155.

‡ *London, Mon. Not. R. astr. Soc.,* 73, 1913, p. 549.

§ *Southport, Fernley Observatory, Report* for 1916, p. 8.

|| *London, Mem. R. met. Soc.,* 2, No. 12, pp. 13 and 19.

¶ *London, Quart. J. R. met. Soc.,* 42, 1916, p. 168.

** *London, Quart. J. R. met. Soc.,* 41, 1915, p. 323.

every five and thirty years the same kind and suit of years and weather comes about again ". But this is only half the story and evidently applies essentially, or at least, primarily, as stated, to certain countries on the other side of the North Sea. When, apparently, Bacon had more fully investigated the matter, probably from English traditions, he altered his view as to the length of the period ; for in " A New Edition, corrected " of that notorious little book on the " Shepherd of Banbury's Rules to judge of the Changes of the Weather ", a profusely commentative editor of the Shepherd (John Claridge)'s " Rules ", remarked that :—" Lord Bacon, that Honour to our Nation and the Age which produced him, informs us, that it was an old Opinion there was a total Revolution of the Weather once in forty years, and wishes it were enquired into ". (This " new edition, corrected " of the little book, seems to have been published for one Thomas Hurst, by Edward Chance & Co., of 65, St. Paul's Church-Yard, London, in 1827.)

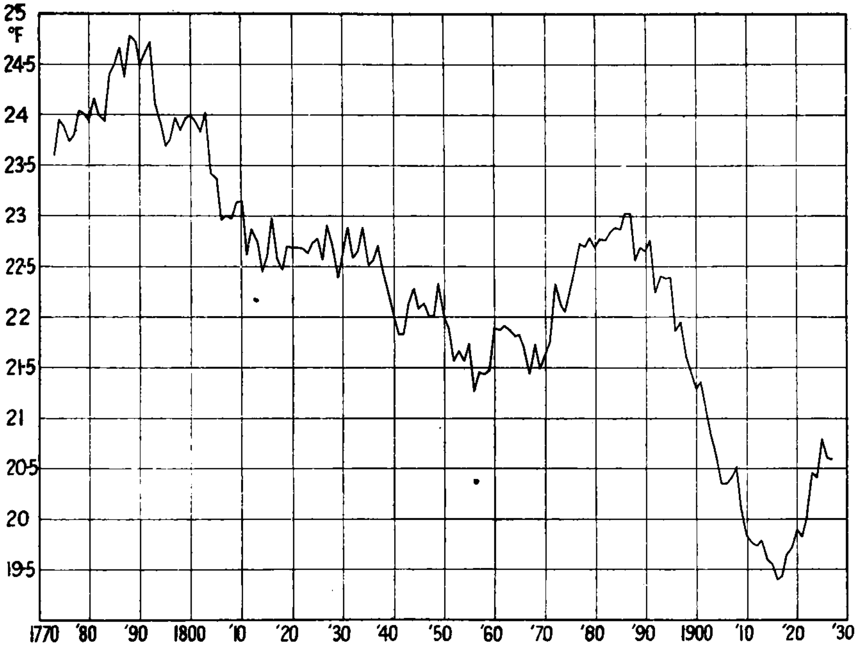

FIG 1.—20-YEAR MOVING AVERAGES OF MEAN SUMMER TEMPERATURE MINUS WINTER TEMPERATURE IN LONDON.

So much for what we may now definitely term the 39± year periodicity. But in Miss Lewis's Fig. 6, we are confronted with an entirely different course of affairs. Clearly, the only cycle indicated there is a much longer one—possibly the rainfall and wind direction, etc., term of over half a century. It is obvious that annual mean temperature, and the annual *range* of mean temperature (or at any rate, the difference between mean winter and mean summer temperatures), are each governed by entirely different laws to the other, so far as the general major variations of their curves down the decades and centuries are concerned. As it seemed of great interest to ascertain how this winter-summer range curve had been running before the commencement of the Oxford records used by Miss Lewis, I ventured to ask Dr. Brooks to be good enough to prepare a diagram similar to the former's Fig. 6, but based on London data (of which he and I had, years ago, got together an extensive list). This he did, and with his kind permission, the diagram is published here as Fig. 1. It will be seen that it well supports the Oxford one given on page 12 of *Professional Notes* No. 77, and also reveals another and most striking maximum very nearly a century before Miss Lewis's last; and a less marked one occurring not quite half-way between these two. Incidentally, the new longer curve, by its high earlier portion renders increasingly remarkable the great minimum of difference between winter and summer temperature that occurred during the second decade of the present century. (The annual values are running means of 20 years, but they are here plotted to their centering dates.)

A noteworthy indication of the possible importance of the half-century rainfall period is afforded by a diagram for the " Southport " district given in a recent paper on the " Fluctuations of annual rainfall in south Lancashire and north Cheshire ", by Mr. D. A. Boyd*, which shows it in a very pronounced form ; whilst in his " Neston " curve, representing the Wirral area of Cheshire, its amplitude is greatly reduced, the consequence evidently of that district's lying under the " rain-shadow "of Snowdonia. This seems to indicate clearly that the rains subject to the 52± year periodicity consist largely of orographic precipitation of vapour of Atlantic origin, and therefore that the catchments on the high western gathering grounds for the water supplies to several of our largest English cities may be seriously affected by the long, generally drier period upon which, according to all the relevant data in our possession, we are now entering—if, indeed, we have not already entered into it.

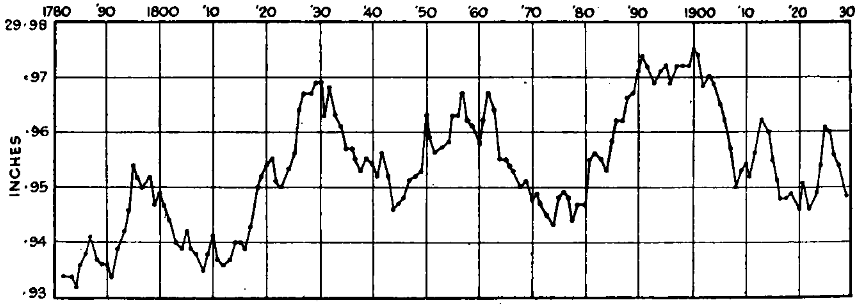

FIG. 2. LONDON AIR PRESSURE, 1774–1936

There remains to be mentioned a cycle of 33 or 34 years. This has long been suggested by various writers, but in this country is, apparently, most pronounced in air pressure, at any rate in

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* *London, Quart. J. R. met. Soc.*, 63, 1937, p. 504.

London, where, as will be seen from the accompanying Fig. 2 (the greater part of which Mr. Charles Baxendell computed for me many years ago at the request of Mr. Alex. B. MacDowall—who was searching for Brückner's period), it extends back to the earliest records that Mr. R. C. Mossman and Mr. H. S. Eaton were able to find and to adjust (they hoped) so as to connect to the Greenwich series. The annual values of pressure have been smoothed by forming running means of 17 years and plotting these to their centering dates. A most obvious lesson to be drawn from the curve is that the chief long-period variations of atmospheric pressure have nothing in common with those of either temperature or rainfall—in England. But Dr. Brooks and Miss Hunt *have* found a 34-year term in London wind-direction*, and Dr. Brooks has shown that a periodicity of between 33 and 34 years is well-marked in the 800 years Nile-flood data mentioned above, while earlier still, E. Huntington and H. L. Moore, in America, had asserted that such a cycle was apparent in the tree-rings of the great Californian *Sequoias*, and in the rainfall of Ohio and elsewhere, respectively. Since the end of the first decade of the present century this old-established periodicity (like several other particularly well-authenticated ones) has shown strange abnormalities. There can be little doubt that the last true minimum and maximum were those shown in the diagram at 1908 and 1925, respectively, and that the anomalous ones seen between these were occasioned by some disturbing influence.

I should, perhaps, add that very accordant indications have been found in the British Isles of a feebler periodicity of 22½ years—the magnetic sunspot cycle, which is so well-developed in the incidence and duration of the winter rains at Adelaide, South Australia, as Mr. E. A. Cornish has recently shown†, and in which Dr. F. J. W. Whipple is particularly interested. I have reason to hope that Dr. C. E. P. Brooks will shortly publish some particulars of its manifestation in our Islands.

[Note by Dr. C. E. P. Brooks]. At Mr. Baxendell's suggestion I add a note about the results of a preliminary study of the long period cycles in the atmospheric circulation over the British Isles. The data are the same as those in the investigation of the 5 year cycle, described in the *Meteorological Magazine* for October, 1937. The pressures and resultant winds at London and Edinburgh and the pressures at Paris cover more than 150 years but even this includes only three or four repetitions of these long cycles, and for the other stations the records are shorter. The material is insufficient to eliminate interferences and irregularities and the results are to that extent uncertain. Phase angles refer to a zero at Jan. 1st, 1937 ; resultant winds are given in degrees from north through east ; they are of course minor fluctuations superposed on the normal prevailing south-west wind.

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* *Met. Mag., London,* 68, 1933, p. 155.

† *London, Quart. J. R. met. Soc.,* 62, 1936, p. 481.

The 52 year cycle does not appear consistently in the pressures at Edinburgh, London or Paris. The resultant winds are more consistent, the phase differences between the last two cycles at London and Edinburgh respectively being :— N. component 20° and 37°, E. component 63° and 58°. The resultant directions at multiples of 52 years before Jan. 1937 were : London 98° ; Dublin 98° ; Edinburgh 2°. As the cycle progresses the resultants at London and Dublin swing rapidly through north to west, but the oscillation at Edinburgh is almost entirely confined to the north component. As Mr. Baxendell points out, the 52 year cycle appears prominently in the rainfall of England, but the nature of the association between wind and rainfall is not yet clear.

The 39 year cycle appears fairly regularly in the pressure data for London and Paris, at each of which the phase angles of the last three cycles all fall within a range of 90° ; the maximum pressure appears to come about two years earlier at London than at Paris. At Valentia, Edinburgh and Stykkisholm the pressures do not show show this cycle. It does not appear clearly in the resultant winds at London, but the N. component at Edinburgh is consistent over three cycles. The resultant winds at multiples of 39 years before Jan. 1st, 1937 are : London 263°, Dublin 16°, Edinburgh 180°. This is near the maximum of the pressure cycle at London, and it seems probable that the mechanism of the 39 year cycle consists of a rise and fall of pressure over south-east England and northern France, with outwardly directed winds at maximum pressure and inwardly directed winds at minimum pressure.

The 34 year cycle is consistently shown in the pressure at London, where four successive cycles give phase angles (at Jan. 1st, 1937) of 168°, 181°, 199° and 187° respectively ; at other stations it is much less regular. On the other hand it is not well shown in the winds of London, but comes out clearly in Edinburgh, where three successive cycles show a range of less than 90° in the phase angles of both north and east components. The nature of this cycle appears to be similar to that of 39 years, namely an oscillation of pressure over eastern England with alternately out-flowing and in-flowing winds at Edinburgh and Dublin, but the details are not yet clear. Unfortunately the data are not sufficient to separate the 34 and 39 year cycles completely, for which about 250 years would be required.

The Climate of the British Isles

It has been remarked that the British Isles have plenty of weather, but little climate. Mr. Bilham's massive book* does not bear out this libel, for he finds much to say about all the usual climatic elements and a few that are less commonly treated. As Superintendent of the division of the Meteorological Office which deals with British Climatology and British Rainfall, he is in a unique position to assemble the material for such a purpose, and his book is authoritative to a degree far beyond anything hitherto published for these islands.

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* The Climate of the British Isles, being an introductory study of the official records, for students and general readers. By E. G. Bilham. Macmillan & Co., Ltd., London, 1938. *Illus.* Size 6 in. × 8¾ in. Pp. xix + 374. 21*s.* net.

The opening chapters are introductory, the first dealing with the scope of climatology and giving some necessary explanations about the methods of deriving values of the different elements, while the second describes the geographical conditions which make for our temperate climate. The third chapter is mainly synoptic, relating the various types of weather to characteristic pressure distributions on the basis of Colonel Gold's classification of weather charts. It is interesting to note that these types, which are presumably selected for their importance as constituents of climate, are named from the intermediate points of the compass—south-west, north-west, etc. (apart from the non-directional cyclonic and anticyclonic), while the older classification of Abercromby, which aims rather at persistence of type, refers to the cardinal points—westerly, southerly, etc. Bilham's classification seems an improvement but one would have liked to see a reference to Abercromby's pioneer work.

With the chapter on " wind " we enter on the real statistical discussion. Figures of direction and force or velocity are given for representative stations, discussed and illustrated both in their geographical distribution and annual variation, and considerable attention is devoted to the subjects of gales and violent gusts, and of land and sea breezes.

Rainfall, as would be expected, is discussed in great detail, and as with wind, attention is not directed solely to average quantities but also to frequencies and extreme values. There is a coloured folding chart of the annual average. The succeeding chapter, " Evaporation and Percolation ", describes what happens to the rainfall after it has reached the ground. All this part of the book will be of great value to water engineers.

The chapter on " Temperature of the Air " is based mainly on the observations for the period 1906–1935 but longer records are also utilised, especially that at Oxford. The duration of bright sunshine is next discussed exhaustively. Britain is the home of the Campbell-Stokes sunshine recorder and information about the distribution of sunshine is probably more complete for this country than for any other in the world, a highly satisfactory position in view of the importance of this element for health. Estimates of cloud amount are much less reliable as a substitute and are only briefly discussed. Variations of atmospheric humidity are considered from many aspects, and the various tables and diagrams based on an analysis of the data from the principal observatories satisfy a long-felt want. In Chapter X we have statistics of the frequency of " weather "—ground frost, snow, hail and thunder, with accounts of great snow and hailstorms. Another subject on which systematised treatment was badly needed was visibility ("atmospheric obscurity") and here again the need is abundantly met.

The last chapter deals with special types of climate, i.e. coastal compared with inland, the peculiar local climates of narrow valleys, and towns, exemplified by London. Although our "mountains" are not very high, it would have been of interest if the author had given also a section on "hill climates", especially in connexion with winter sports, but high-level stations are frequently referred to in connexion with the individual elements. An appendix gives monthly averages and extremes for 39 stations well distributed over the British Isles.

This inadequate summary will suffice to show that the book is extraordinarily thorough and painstaking. There are no fewer than 101 illustrations and 63 tables (in addition to the climatic summaries in the appendix), and the labour of proof-reading alone, quite apart from the compilation, must have been arduous. Yet the reviewer noticed only one serious error—in Fig. 57. The index occupies 13 pages and is very thorough, but some of the entries might have been sub-divided; for example the entry for Valentia Observatory gives 38 page numbers with no indication of which element is referred to on any one page. The bibliographies at the end of each chapter are generally adequate though not in correct bibliographical form.

Where so much is given, it may seem ungracious to ask for more; but there are two points which call for comment. The first is that solar radiation although frequently mentioned incidentally, is almost ignored as a climatic element apart from simple duration of sunshine. There is only one casual reference to ultra-violet radiation, which is probably the most important single quantity in the medical climatology of these islands. Admittedly the meagre data available would have been difficult to handle, but even to call attention to the deficiency would have been a valuable service. The second comment is that the author writes throughout almost as if the climate of a place is a fixed attribute instead of an abstraction depending on the period of observations. Cyclical variations of long period and secular changes are dismissed in a few words although they are not only of great interest in themselves but quite possibly of real economic importance. The rarity of severe frosts during the present century, for example, is a climatic fact of considerable significance to the householder.

For the "general reader" the book though quite readable seems likely to be somewhat heavy going, but the geographer and anyone else who requires a specialised knowledge of the climate of the British Isles will find it indispensable. The dust jacket is a trifle startling for a scientific work but otherwise the general appearance and binding are up to the high standard expected of the publishers, and all things considered, the price is most moderate.

C. E. P. BROOKS.

OFFICIAL NOTICE

We have been asked by the President of the International Meteorological Committee to publish the following notice :—

Secretariat of the International Meteorological Organization

Applications are invited for the post of Chief of the Secretariat of the International Meteorological Organization, at present located at De Bilt, Holland, but to be transferred to Switzerland.

The functions of the Secretariat as laid down in the Statutes of the Organization are as follows :—

" Un Secrétariat, fonctionnant sous la direction du Président du Comité Météorologique International, est chargé de l'organisation des réunions de la Conférence, du Comité et des Commissions ainsi que de la publication des Procès-verbaux. Il constitue également un centre de documentation relatif aux Services météorologiques du monde entier et il aide, dans toute la mesure de ses moyens, le Président du Comité et les Présidents des Commissions dans l'exécution de leurs travaux."

Applicants must be able to correspond in English, French and German and to speak two of these languages.

The salary will be £550, rising by annual increments of £20 to £750. Superannuation will be based on a commercial insurance policy, the premium of which will be 15 per cent of the salary, 10 per cent being paid by the employer and 5 per cent by the employee.

Appointments will be made on probation for two years and will be terminable by six months notice on either side.

Applications should be sent before May 10th, 1938, to Dr. Th. Hesselberg, President of the International Meteorological Committee, Det Norske Meteorologiske Institutt, Oslo, Norway, from whom further particulars may be obtained on request.

Royal Meteorological Society

The monthly meeting of the Society was held on Wednesday, March 16th, in the Society's rooms at 49, Cromwell Road, South Kensington; Dr. B. A. Keen, F.R.S., President, in the Chair. Mr. F. Entwistle, B.Sc., F.R.Met.S., Head of the Overseas Division of the Meteorological Office, Air Ministry, delivered the Symons Memorial Lecture on the subject of " Atlantic Flight and its bearings on Meteorology " of which the following is an abstract :—

The series of survey flights carried out across the North Atlantic last year by Imperial Airways Ltd. in conjunction with Pan American Airways Inc. aroused considerable public interest largely owing to the fact that, although the flights were of an experimental character, the operations were effected with the smoothness and efficiency of a scheduled air service.

The success of these flights was due in very large measure to the thorough preparations which preceded them and to the ground organization, including radio and meteorological services, which was provided. On the first double flight on the night of July 5th–6th, the times of departure of the two aircraft from Foynes and Botwood were adjusted on the basis of meteorological forecasts so that they should arrive at their respective destinations as nearly as possible at the same time. Actually they arrived within 10 minutes of each other.

The lecturer referred to preliminary investigations which were carried out by the Overseas Division of the Meteorological Office in order to provide essential operational data before the flights commenced. The first investigation, commenced early in 1936, had as its object the determination of the maximum average head wind component that would be experienced on an east to west track along the Great Circle route between Ireland and Newfoundland. The results, which were based on an examination of data covering a period of 10 years, indicated that while the maximum wind speed likely to be encountered at any point was 95 m.p.h., the maximum average speed over the whole route was 60 m.p.h. This average speed, however, occurred only once in ten years and the investigation showed that if, in the operation of a trans-Atlantic aircraft, an allowance was made for a maximum head wind on the east-west track of 40 m.p.h. there would be very few occasions in any one year when it was necessary to cancel the flight.

A more comprehensive investigation followed in which the times of flight of aircraft of different air speeds on alternative trans-Atlantic routes were compared. The results of this investigation confirmed those of the earlier research besides producing additional valuable data. Later investigations were concerned with the meteorological conditions affecting the operation of aircraft in Newfoundland, the variation of wind with altitude over the North Atlantic and the frequency and minimum heights of low cloud.

Reference was also made to the attachment for one year from November 1936 of a technical officer of the Overseas Division of the Meteorological Office to the "Manchester Port", a cargo ship operating between Manchester and Canada. During this period the meteorological officer completed eight round voyages in the course of which he made regular pilot balloon observations to determine the wind speed and direction at different altitudes, constructed daily weather charts from observations received by radio from Europe and North America as well as from ships at sea, and studied in detail the characteristics of the Atlantic disturbances through which the ship passed.

Turning to the actual meteorological organization brought into operation for the flights the lecturer noted that the Meteorological Office, Air Ministry, operates the meteorological service at the Irish base at Foynes on behalf of the Government of Eire on an agency basis while the Meteorological Service of Canada operates the service at Botwood on behalf of the Newfoundland Government.

The organization involved the preparation of weather charts covering eastern North America, the Atlantic and western Europe at intervals of six hours. Close co-operation was maintained by radio between the meteorological services at Foynes and Botwood, views being exchanged on the development of the meteorological situation. Before a flight commenced the Commander was supplied with a comprehensive weather report, including a detailed forecast of the meteorological conditions likely to be experienced over different parts of the route, and a copy of the latest weather chart on which the forecast was based. This information was supplemented by later advices sent by radio to the aircraft in flight as new information became available.

Approximately half way across the Atlantic the control of the aircraft was transferred from the base of departure to the terminus and the meteorological station at the latter base then took over the supply of information for the remainder of the flight.

A detailed description of the weather conditions experienced during the daylight flight of the " Caledonia " on August 15th was given. It was pointed out that although conditions were far from ideal along the route the flight was completed without incident and the Commander was kept fully informed as to the weather ahead, landing at Botwood in perfect conditions as forecast before he left Foynes.

There followed examples of the research which is being pursued on the meteorology of the North Atlantic. One example included a discussion of the detailed vertical structure of a disturbance through which the " Caledonia " passed on August 20th–21st and illustrated the value of combining information obtained from the aircraft's log with the weather data normally available.

The lecturer, in conclusion, pointed out how these investigations which are essential to the supply of accurate meteorological information for trans-Atlantic flying will benefit meteorological science generally and in particular, the weather forecasting services of the countries of western Europe, the greater part of the weather of these countries developing over and moving from the Atlantic. The development of long distance air routes in various parts of the world is stimulating similar meteorological activity and is providing data for investigation on a scale hitherto unknown.

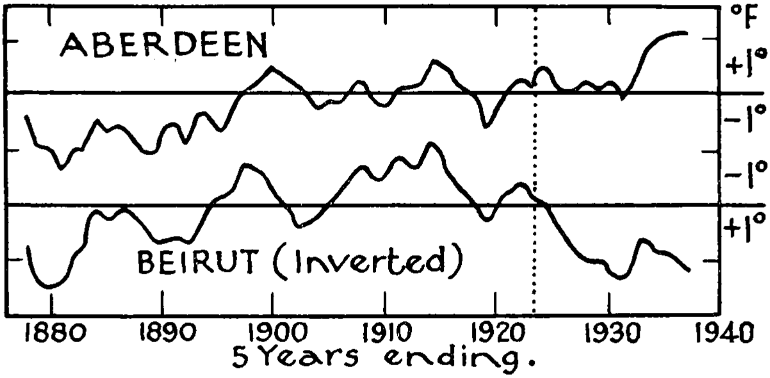
Correspondence

To the Editor, *Meteorological Magazine*

Period Temperature Variations

In the very interesting article on Arctic temperature variations by Dr. Brooks, in the March issue of the *Meteorological Magazine*, it was pointed out that the early 1920's were the critical years during which the rise of Arctic temperatures commenced. Other meteorological changes can also be related to this period, and a clear example of such is shown by the period temperature variations in Scotland compared with those of the eastern Mediterranean sea.

The following figure compares the five-year moving average of temperature at Aberdeen with the inverted curve for Beirut, Syria.



FIVE-YEAR MOVING DEPARTURES FROM THE MEAN, 1901–30

It will be seen that these curves show close temperature opposition from 1875 to about 1923, but from 1924 to 1937 there has been a great change, and except for the years 1930–3, the opposition has quite died out, the 1930's being abnormally warm at both stations.

The observations at the American University, Beirut, and of course at Aberdeen, appear to be thoroughly reliable, and the reversal of this apparently normal temperature relationship presents an intriguing problem in atmospheric circulation for meteorologists to solve.

G. S. CALLENDAR.

Imperial College of Science, S.W.7, March 30th, 1938.

Lunar Corona

There was a marked corona round the moon at about 2115 G.M.T. on the evening of February 11th. It consisted of the usual aureole, one blue ring about $\frac{1}{2}$° wide with a red outer ring, both of which were bright. Two faint outer rings were suspected. The moon was shining through what seemed to be cirrocumulus.

CICELY M. BOTLEY.

Guildables, 17, Holmesdale Gardens, Hastings. February 12th, 1938.

A Green Moon

I observed a green moon at Leuchars, Fife, on the morning of Friday, December 17th, 1937, at a quarter past seven. The moon was 5 degrees above the horizon and 310 degrees from north when the phenomenon first became apparent. The sky was almost cloudless at the time with a trace of stratocumulus cloud, and becoming pale in the south-east with the early dawn. An olive green light appeared to radiate from the moon and the surface of the moon appeared pale green. Patches of cloud passing across the moon also appeared green and had no effect on the phenomenon. The green moon lasted for a quarter of an hour when it slowly became pale yellow deepening to orange as it sank beneath the horizon. The moon was full at the time and was viewed across the expanse of the aerodrome with snow covered hills to the west.

G. FROUDE.

Meteorological Office, R.A.F., Leuchars, Fife, January 11th, 1938.

"Mother of Pearl" Clouds at Eskdalemuir

The notes in the *Meteorological Magazine* of February, 1938, from Aberdeen and Ross-on-Wye show that the layer of iridescent cloud of January 28th–29th, 1938, was an extensive one. It may be of interest to add a note of the observations at the intermediate station Eskdalemuir.

" Mother of pearl " clouds were seen here between 1700–1710 G.M.T. during a brief interval when the sky was nearly clear of low cloud, twenty minutes after sunset. The colours appeared as alternating bands of green and pink on the under side of a thin sheet of cirriform lenticular cloud in beautifully curved striations like the patterns formed by an oil film on a wet surface. At this time the twilight arch was at an elevation of 20° and the first patch of " mother of pearl " cloud made its appearance some 5° higher than the brightest part of the afterglow and to the left of it, in a darker portion of the sky. The remainder of the cirriform sheet was suffused by a strong yellow glow. Three other smaller patches of " mother of pearl " cloud developed more directly above the brightest part of the afterglow just before the sky was again covered by low cloud.

Surface conditions at 1700. Wind force 7–8, between WSW. and W. by N. Visibility 12 miles.

R. F. M. HAY.

The Observatory, Eskdalemuir, Dumfriesshire, March 15th, 1938.

NOTES AND QUERIES

The Weather of 1937 in the Northern Pennines

Temperatures and other observations have been made for a further year at Moor House (1,840 ft.) in Upper Teesdale; summaries have been given in earlier issues of this Magazine and in the *Quarterly Journal of the Royal Meteorological Society* for 1936. The observations for 1937 are summarised in the following table.

The year was notably dry in comparison with 1935 and 1936, and was generally favourable with the exception of the extremely severe March. The temperatures tell their own story; and it was necessary to make estimates for a number of days on which the screen was filled with drifting snow. Indeed during one night over three cwt. of snow was driven, despite a well-fitting door, into the hallway of the house. Summer and autumn, on the other hand, were mild and dry until late in November.

	Mean	Mean Max.	Mean Min.	Extremes and Dates.		Rainfall*	Days* of "Snow-Lying."
	°F.	°F.	°F.	°F.	°F.	in.	
Jan. ...	34·8	38·1	31·5	48 (22)	22 (30)	8·00	15
Feb. ...	32·6	35·5	29·7	45 (3)	19 (24)	8·14	19
Mar. ...	28·4	32·4	24·4	38 (29)	13 (22)	5·72	31
April ...	40·4	45·4	35·4	59 (30)	29 (1, 25)	4·26	7
May ...	46·4	53·3	39·5	67 (29)	33 (6, 16)	4·44	—
June ...	49·5	55·6	43·3	67 (10)	33 (2)	4·54	—
July ...	54·4	61·0	47·8	74 (31)	40 (30)	3·52	—
Aug. ...	55·9	64·5	47·3	76 (3)	33 (27)	3·36	—
Sept. ...	48·7	54·4	43·0	65 (7)	33 (19)	4·76	—
Oct. ...	44·0	49·2	38·8	60 (19)	31 (5)	3·08	—
Nov. ...	36·3	39·9	32·7	51 (1, 3)	22 (14, 20)	1·37	8
Dec. ...	30·9	34·5	27·3	45 (1)	11 (? 18)	3·44	26
Year ...	41·9	47·0	36·7	76 (3.viii)	11 (?18.xii)	54·63	106

* Approximate ; the exposed situation makes for difficulties.

Despite the rather large number of days with " snow-lying " the year was probably rather exceptional in that scarcely a shower of snow or sleet occurred between mid-April and mid-November. Estimates for " snow-lying " are difficult to make on hilly ground largely composed of peat-hags and so the figures given must only be regarded as approximate.

During the last three months of the year the writer has obtained approximate records of temperature from a " mountain-top " station 3 miles west of Moor House, near Dun Fell, the second highest summit of the Pennines. The station itself is almost on the ridge, at an altitude of 2,710 ft., and is easily the highest at which a continuous record has yet been attempted in England. It is hoped that the data will be of value in relation to an investigation of the " helm wind " ; so far, however, the " helm " has occurred on too few days to justify even preliminary conclusions. The experience gained from such a severely exposed locality, however, may be of interest.

During October and early November the chief troubles arose from persistent complete saturation of thermograph charts, but this was overcome to some degree by using artists' varnish. The trace of the pen, while thin, was quite good. But with the advent of frost over long periods, alternating with thaw and mist, ice formation on and about the bimetallic coils, hindering movement, took place so often that one thermograph was kept running by the ventilator of the observing hut, giving a rough record only, while attempts were made to devise further protection for the thermograph in the screen. Again, irregular behaviour of the clocks was probably due to ice formation in the teeth of the driving pinion : frequent coating with fine oil did not overcome this. The covering of the instruments by drifting snow was temporarily overcome by arranging cardboard baffles inside the screen. Next, the screen was erected on the roof of the hut, in the hope that a position might be found in which drifting snow would be carried round the screen rather than into it. But more serious troubles developed during December and early January, due to excessive ice-formation and deposition of rime ; e.g. frost-feathers eighteen inches long grew to windward of the screen after two days' exposure to strong SW. wind. The general coating over the sides and roof of the hut and screen was about three inches thick. This ice-deposit completely sealed the screen at times and was so hard that it could only be dislodged by vigorous blows with an ice-axe. Another position for the screen is now being tried, with reasonable success so far. The writer is considering whether a type of screen with much larger louvres and a hinged base might not be better for such a locality, despite the fact that Stevenson screens have been used effectively in high latitudes. The bimetallic thermographs have been replaced by a mercury-in-steel type, which the writer was fortunate enough to obtain at short notice, and which is working well.

The experience as a whole has been rather surprising, inasmuch as the bimetallic thermograph in an ordinary screen at Moor House has given comparatively little trouble over several years. The additional 900 feet of altitude however, with much more frequent mist and even stronger winds, makes an unexpectedly large difference to the conditions of operation. The experience of going to and from the station in all weathers is also of distinct interest. South-westerly winds, in accordance with the location, are very strong near the ridge, but the hut has withstood the gales well, largely because its base is in a small hollow. One recent measurement of force 9 was made, for example, when the average at west coast stations seems to have been about force 7 from SW.

The following figures may be given ; they are of course only approximate :—

Altitude 2,710 *ft.*

	Mean.	Mean Max.	Mean Min.	Extremes.	
	°F.	°F.	°F.	°F.	°F.
October ...	41·0	44·4	37·7	55 (19)	29 (27)
November ...	33·3	36·0	30·7	48 (5)	21 (13–14)
December ...	28·7	31·5	26·0	43 (24)	16 (? 12)
January ...	32·4	36·0	28·8	43 (23)	23 (27)
February ...	30·6	34·1	27·1	44 (26)	20 (11, 15)
March ...	38·1	41·5	34·7	49 (11)	23 (26)

As might be expected, temperature remains very uniform over long periods, and the apparent daily range is largely an expression of the frequency of irregular fluctuations, notably during the last three weeks of January with persistent and strong westerly winds. Now that a number of experimental difficulties have been overcome it is hoped that a reasonably good record will be forthcoming, which promises to be of interest, for example in comparison with the "free-air" averages from Mildenhall and Aldergrove.

GORDON MANLEY.

Temperatures at Rickmansworth, 1937

At the end of February 1937, it became necessary to close down the climatological station which had been maintained near the bottom of a deep, enclosed valley between Rickmansworth and Chorley Wood, Herts, since May 1929. Through the courtesy of Lieut.-Comdr. R. F. Sheppard, R.N., a Stevenson screen, containing maximum and minimum thermometers and a thermograph, was set up in his grounds within 50 yards of the site of the existing station and at approximately the same elevation (182 ft.) above sea level, in November 1936. Over the period of 3½ months during which the old and new stations were at work together the differences of temperature between them seldom exceeded 1° F. The general agreement was such as to justify the assumption that thermal conditions at the two sites are almost identical, and the records kept by Lieut.-Comdr. Sheppard since March 1937, may thus fairly be regarded as a continuation of the original series.

Month.	Mean values.			Extremes.			
	Max. A °F.	Min. B °F.	$\frac{A+B}{2}$ °F.	Max. °F.	Date.	Min. °F.	Date.
Jan. ...	46·7	31·5	39·1	53	6, 23	18	20
Feb. ...	48·5	32·5	40·5	55	4, 15	20	12
Mar. ...	45·2	28·5	36·9	57	20	16	10
Apr. ...	56·6	38·7	47·7	63	6	22	1
May ...	64·3	40·5	52·4	83	29	27	6
June ...	69·3	41·3	55·3	83	11	31	30
July ...	71·1	48·5	59·8	86	3	35	8
Aug. ...	75·4	47·9	61·7	91	6	36	16
Sept. ...	65·7	40·2	52·9	82	7	26	21
Oct. ...	59·7	38·6	49·1	67	1	26	16
Nov. ...	46·5	29·4	37·9	58	2	13	21
Dec. ...	41·2	28·1	34·7	53	22, 23	15	6, 19
Year ...	57·5	37·1	47·3	91	Aug. 6	13	Nov. 21

As the climate of this Hertfordshire valley is one of the most notably "continental" yet discovered in England, and as the Rickmansworth returns did not appear in the *Monthly Weather Report* after February, a summary of the temperature data for 1937 may be of interest here. In the above table the mean values for each of the ten months March to December are derived from the thermograph charts, while the extremes are from the standard maximum and minimum thermometers throughout the year.

For the sixth year in succession the mean diurnal range of temperature exceeded 20° F. The variations in this figure have been curious: there was a regular increase from 18·9° F. in 1930 to 22·7° F. in 1934, followed by an equally regular decrease to 20·4° F. in 1937. The greatest individual range last year was one of 43° F., from 39° F. to 82° F., on June 6. On June 30 the latest "spring" frost yet recorded at the station was registered, the minimum in the screen being 31° F. A thermometer exposed over grass (which was not always kept so short as it should have been) fell to 6° F. in December, and to 7° F. in March and November.

E. L. HAWKE.

"Such stuff as dreams are made on"

Before 0800 G.M.T. on September 29th, cirrus cloud in a direction 215° from South Farnborough attracted attention by its slow movement: it was white and opaque and seemed at first to be moving very slowly away. At 1000 it seemed to be stationary and at a height, one would say, of about 20,000 ft. judging by its whiteness: a photograph (reproduced as frontispiece to this number) was taken at this time. Later the cloud appeared to be approaching slowly and eventually arrived overhead at 1300 when it appeared as a characteristic tangled web, with blue sky in the interstices, moving slowly from 220°.

An anticyclone was over the Channel at the time and the previous evening cirrus was moving from about 340° at several stations. On the morning in question Biggin Hill reported 80° 10 m.p.h. and later in the day 220° 35 m.p.h. The movement of the cloud under observation during the morning seemed to be about 20 miles in 5 hours.

Fortunately I had been consulted by a pilot as to the weather for a flight to 33,000 ft. to be carried out in the early afternoon and I was able to ask him to observe the substance of this cloud, then overhead, which he would probably penetrate. After the flight I found out that no cloud was reached until about 32,000 ft. and although the cloud was clearly visible from the ground it was invisible while the observer was actually in it. From slightly below and slightly above it appeared as an almost imperceptible film which might easily be ignored: this may account for the scarcity of observations of the nature of cirrus cloud. The pilot put out his hand to feel, if possible, whether ice crystals or the like were present: he felt an extremely fine, dry, powdery dust blowing past his hand. No halo phenomena were observed.

A similar filmy layer was observed at about the same height on another flight in the summer of 1937.

R. M. POULTER.

OBITUARY

We regret to learn of the death on January 21st, at the age of 79, of Dr. Julius Maurer, formerly Director of the Eidgenössische Meteorologische Zentralanstalt of Switzerland.

NEWS IN BRIEF

Prof. B. F. J. Schonland, Professor of Physics of the University of Cape Town, has been elected a Fellow of the Royal Society.

Dr. Rudolph Geiger has been appointed Professor of Physics and Meteorology at the Forstlichen Hochschule, Eberswalde, Germany.

Mr. Alfred Goodwill, who retired from the post of chief observer at the Fernley Observatory, Southport, in January last, had been associated with the work of the Observatory since 1894, when he was appointed deputy observer. During his long period of service under Mr. Joseph Baxendell, Mr. Goodwill gained a high reputation as a skilled observer and computer. At a social gathering of his friends and colleagues on January 17th, Mr. Goodwill was presented with a clock as a token of their esteem. On behalf of the many meteorologists to whom Mr. Goodwill is well known we offer our good wishes in his retirement.

We understand that Miss K. Sprague, Anglefield, Berkhamsted, Herts, wishes to dispose of the meteorological instruments formerly the property of Mr. E. T. Browne, whose death occurred in December last. Any reader who is interested should communicate direct with Miss Sprague.

The Weather of March, 1938

Average pressure for the month was very high over much of western Europe, particularly over southern England and France where it exceeded 1025 mb. In these regions and also in northern Italy and Sardinia pressure was more than 10 mb. above normal. Northwards of this anticyclonic region average pressure diminished, falling below 1000 mb. over Iceland, southern Greenland, northern Scandinavia, Bear Island and Novaya Zemlya. Over these latter regions, also over Russia north of 50°N. and much of northern Canada pressure was 10 mb. below normal. The Siberian winter anticyclone had decreased in intensity, and over Siberia pressure was generally below normal. Pressure was below normal also over North America.

The anticyclonic weather in western Europe produced abnormally high temperatures; north of about 45°N. in most of Europe, with the exception of Norway, temperatures were 5°–8°F. above normal. Much of the Arctic and of northern Siberia were also abnormally warm; Spitsbergen (13·6°F.) was 9°F. and Matotchkin Char (6°F.) was 8°F. above normal. Temperatures were above normal over most of North America; in the United States east of 100°W. the excesses were between 5° and 10°F., and in a region stretching from south to north in central Canada the excesses were more than 10°F. In the extreme east of Canada, however, the weather was slightly colder than usual.

In Europe precipitation was nearly everywhere deficient except locally in the north, where Stornoway had an excess of 3 in. and the Faeroes an excess of 6 in. In North America, also, precipitation was below the normal in most regions, a notable exception being St. Louis with over 9 in.

The weather of Marc l was abnormally warm, exceptionally dry and very sunny in England. The persistently high day temperatures throughout almost the whole of Great Britain during the month are unparalleled in British weather records. The mean maximum temperatures of 58·3° F. at Kew and 54·7° F. at Aberdeen exceed those of any March since 1870, and Greenwich with a mean maximum temperature of 59·3° F. established a record for a century. Daily maxima of 60° F. and above were unusually frequent. "Absolute drought" prevailed from the 1st over south and east England, the Midlands and east Scotland for a period of 16 to 23 days. At Ross-on-Wye it was unbroken on April 1st after 33 days, the total fall of 0·5 mm. being the lowest for the month since 1859. Sunshine was below normal in the north-western half of the British Isles, but was increasingly above normal south-eastwards, stations in Kent having totals of over 200 hrs. Gales were frequent in Scotland. A ridge of high pressure moved eastwards over the British Isles on the 1st and anticyclonic conditions prevailed until the 14th. Temperatures were low in Scotland and the north on the 1st and some snow fell. Hail fell in Ireland and on the east coast, and Portsmouth reported a gale. Maximum temperatures rose generally to the 5th—in some places as much as 20° F.—and remained above 60° F. in England except in the north-west. Sharp ground frosts occurred at night, grass minima of 16° to 18° F. being recorded in places on the 4th, and there was early fog generally from the 4th to 13th. Good sunshine records of 7 to 10 hrs. daily were obtained in all districts from the 1st to 5th, in England until the 7th, and in the Midlands, the south and east until the 9th, Guernsey recording 10·6 hrs. on the 5th. Gales were reported from Scotland on the 2nd to 5th and on the 9th, when Eskdalemuir experienced a gust of 73 m.p.h. Temperature rose in Scotland to the 11th, Dundee having a maximum of 65° F., but fell in England. The 13th and 14th were very sunny with 10 hrs. on each day in many places. Rothesay had thunder on the 14th. Depressions moving north-east off the coast of Scotland brought rain to Scotland and Ireland on the 15th, the heaviest fall of the month, 2·01 in., occurring at Tourmakeady, Duimbawn Ho., Co. Mayo. Winds were strong from the south, and gales were reported from Markree on the 18th, and from Scotland on the 15th, 17th and 18th. Slight rain on the south coast broke the drought on the 16th, but good sunshine records were still obtained daily, particularly on the 19th, 22nd and 23rd, Jersey having 11 hrs. on the 23rd. Temperatures were very high in south and east England on the 20th, Norwich recording a maximum of 69° F., and a minimum of 58° F.; and maxima of 66° to 68° F. being general in the east. Shallow depressions moved north-eastwards across the country on the 20th and Scotland and north-west England and Wales had rain, 1·60 in. falling in Anglesey: hail fell in Ireland. Fog was general in the mornings of the 22nd and 23rd when a ridge of high pressure extended across England. Day temperatures remained high but minima were low, Rhayader recording 24° F. in the screen, and 13° F. on the grass on the 23rd. Rain fell heavily in Scotland on the 23rd, 1·63 in. at Fort Augustus, and snow and hail on the 24th and 25th, also in the north of England. There was little or no sunshine in England on the 25th, but Scotland enjoyed 5 to 6 hrs. The 26th–31st were again sunny though temperatures were lower on the 26th and 27th. Sunshine generally exceeded 10 hrs. on the 31st, Ross-on-Wye recording 11·8 hrs. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.).		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ..	55	−54	Chester ..	123	+ 9
Aberdeen ..	103	− 6	Ross-on-Wye	163	+47
Dublin	98	−17	Falmouth ..	157	+21
Birr Castle ..	90	−21	Gorleston ..	165	+37
Valentia ..	86	−30	Kew.. ..	173	+65

Kew, Temperature, Mean, 49·5, Diff. from average + 5·6.

Miscellaneous notes on weather abroad from various sources.

Fog was experienced off the Isle of Wight on the 5th. Severe gales were reported from the Lofoten Is. on the 2nd, from Iceland on the 5th, when an entire hamlet was blown away, and from the north-west and west coasts of Norway where much damage was caused to shipping on the 6th. Fog occurred off the Dalmatian coast on the 22nd and 27th, and off the Belgian coast on the 23rd. (*The Times*, March 7th to 28th).

After unusually high temperatures for March, Hong Kong had a brief hailstorm on the 9th for the first time on record. 25 people were killed and 150 injured by a tornado which swept a number of villages in the Dacca district of Bengal on the 15th. (*The Times*, March 10th to 19th).

Torrential rainstorms from February 27th to March 2nd caused extensive floods in Southern California. Over 200 people are reported dead or missing, and damage to property is estimated at £5,000,000. A tornado which swept southern Missouri and Illinois on the 15th caused the death of 18 persons and much damage to property. Heavy snow fell in the prairie district of Canada on the 22nd, while in the east serious floods followed the rapid melting of snow. Tornadoes caused extensive damage and much loss of life in the Middle Western States on the 30th. (*The Times*, March 4th to April 1st).

Daily Readings at Kew Observatory, March, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain.	Sun.	REMARKS (see vol. 69, 1934, p. 1).
	mb.		°F.	°F.	%	in.	hrs.	
1	1022·3	W.3	48	54	54	0·04	6·9	r_0–r 0h.–4h., pr 16h.
2	1037·1	WSW.3	33	53	50	—	6·1	x early.
3	1037·8	SW.3	35	58	56	—	9·1	x early, f–F 7h.–8h.
4	1040·3	WSW.2	33	58	63	—	9·8	x early, F 21h.–24h.
5	1037·3	WSW.3	34	60	62	—	7·0	Fe–f 0h.–10h.
6	1032·8	WSW.2	34	59	43	—	8·6	x early, m 9h.
7	1030·7	WSW.1	33	53	77	—	2·9	x early, f all day.
8	1024·0	SW.2	31	60	70	—	5·9	x early, f–F till 10h.
9	1020·9	WSW.3	37	60	62	—	8·6	w early.
10	1025·4	WSW.3	46	58	77	—	0·6	f 21h.
11	1030·9	NNE.2	44	60	70	—	4·8	f till 8h., mw 21h.
12	1036·5	E.3	47	54	64	—	2·1	
13	1033·9	E.2	34	55	57	—	2·2	f–Fe till 8h., m 9h.
14	1024·5	S.3	33	56	33	—	10·5	x early.
15	1024·0	SW.3	35	56	74	—	3·1	f–Fe till 10h.
16	1019·6	SSW.4	45	58	62	—	3·6	
17	1024·5	SW.3	49	54	80	—	0·3	id_0 7h.–9h.
18	1025·6	SW.4	45	57	62	—	3·1	id_0 7h.–9h.
19	1021·5	SSW.5	41	62	40	—	10·5	x early.
20	1014·0	S.4	41	65	42	—	7·7	
21	1009·3	SSW.4	48	61	61	—	6·4	
22	1016·3	ENE.2	42	61	63	—	5·0	z 9h.
23	1020·4	WNW.1	43	62	73	—	5·9	f 0h.–10h., 20h.–24h.
24	1019·5	WSW.4	34	62	53	—	8·5	f 0h.–8h., ir_0 21h.–24h.
25	1009·2	SW.3	48	54	90	0·18	0·0	ir_0–r 0h.–18h.
26	1017·7	WNW.4	37	49	49	0·04	7·9	r_0–r 21h.–24h.
27	1015·1	W.4	43	57	65	Trace	1·9	r_0 0h.–1h., pr_0 10h.
28	1024·9	SW.2	48	62	64	—	2·0	
29	1024·0	W.3	45	63·	63	—	5·1	
30	1024·6	W.4	49	64	60	—	7·8	w early.
31	1026·2	W.3	49	64	59	—	9·1	
*	1024·9	—	41	58	61	0·26	5·6	* Means or Totals.

General Rainfall for March, 1938

England and Wales	27	per cent of the average 1881–1915.
Scotland	97	
Ireland	65	
British Isles ...	52	

Rainfall: March, 1938: England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square..........	·34	19	*Leics* .	Thornton Reservoir ...	·35	19
Sur .	Reigate, Wray Pk. Rd..	·37	16	,, .	Belvoir Castle...........	·22	12
Kent .	Tenterden, Ashenden...	·54	25	*Rut* .	Ridlington	·28	16
,, .	Folkestone, Boro. San.	·71	...	*Lincs* .	Boston, Skirbeck.........	·25	16
,, .	Margate, Cliftonville....	·45	28	,, .	Cranwell Aerodrome...	·27	19
,, .	Eden'bdg., Falconhurst	·59	24	,, .	Skegness, Marine Gdns.	·16	10
Sus .	Compton, Compton Ho.	·63	23	,, .	Louth, Westgate.........	·16	8
,, .	Patching Farm..........	·50	23	,, .	Brigg, Wrawby St.......	·23	...
,, .	Eastbourne, Wil. Sq....	·67	30	*Notts* .	Mansfield, Carr Bank...	·18	9
Hants.	Ventnor, Roy.Nat.Hos.	·42	20	*Derby*.	Derby, The Arboretum	·29	16
,, .	Southampton,East Park	·34	15	,, .	Buxton, Terrace Slopes	1·55	38
,, .	Ovington Rectory.......	·28	11	*Ches* .	Bidston Obsy.............	1·02	54
,, .	Sherborne St. John......	·20	9	*Lancs*.	Manchester, Whit. Pk.	1·09	48
Herts .	Royston,Therfield Rec.	·38	21	,, .	Stonyhurst College......	1·78	48
Bucks.	Slough, Upton............	·25	14	,, .	Southport, Bedford Pk.	1·03	46
Oxf .	Oxford, Radcliffe.........	·35	21	,, .	Ulverston, Poaka Beck	2·02	52
N'hant	Wellingboro, Swanspool	·14	8	,, .	Lancaster, Greg Obsy.	1·37	43
,, .	Oundle	·15	...	,, .	Blackpool	1·37	58
Beds .	Woburn, Exptl. Farm...	·32	19	*Yorks*.	Wath-upon-Dearne......	·19	11
Cam .	Cambridge, Bot. Gdns.	·39	27	,, .	Wakefield,Clarence Pk.	·32	18
,, .	March......................	·27	17	,, .	Oughtershaw Hall.......	3·58	...
Essex .	Chelmsford,County Gdns	·37	21	,, .	Wetherby, Ribston H..	...	...
,, .	Lexden Hill House......	·42	...	,, .	Hull, Pearson Park......	·21	12
Suff .	Haughley House.........	·54	...	,, .	Holme-on-Spalding......	·24	13
,, .	Rendlesham Hall........	·39	23	,, .	Felixkirk, Mt. St. John.	·23	12
,, .	Lowestoft Sec. School...	·56	35	,, .	York, Museum Gdns....	26	15
,, .	Bury St. Ed., WestleyH.	·70	37	,, .	Pickering, Houndgate...	·22	11
Norf. .	Wells, Holkham Hall...	·23	14	,, .	Scarborough...............	·18	10
Wilts .	Porton, W.D. Exp'l. Stn	·21	11	,, .	Middlesbrough............	·04	3
,, .	Bishops Cannings........	·27	12	,, .	Baldersdale, Hury Res.	1·52	49
Dor .	Weymouth, Westham.	·30	15	*Durh* .	Ushaw College............	·34	15
,, .	Beaminster, East St....	·23	8	*Nor* .	Newcastle, Leazes Pk...	·37	18
,, .	Shaftesbury,Abbey Ho.	·22	9	,, .	Bellingham, Highgreen	2·09	71
Devon.	Plymouth, The Hoe....	·31	11	,, .	Lilburn Tower Gdns....	·74	28
,, .	Holne, Church Pk. Cott.	·44	8	*Cumb*.	Carlisle, Scaleby Hall...	1·54	63
,, .	Teignmouth, Den Gdns.	·25	10	,, .	Borrowdale, Seathwaite	11·50	110
,, .	Cullompton	·17	6	,, .	Thirlmere, Dale Head H.	6·83	105
,, .	Sidmouth, U.D.C........	·19	...	,, .	Keswick, High Hill......	3·56	79
,, .	Barnstaple, N. Dev.Ath	·47	18	,, .	Ravenglass, The Grove	1·97	64
,, .	Dartm'r,Cranmere Pool	1·40	...	*West* .	Appleby, Castle Bank...	1·94	72
,, .	Okehampton, Uplands.	·71	17	*Mon* .	Abergavenny, Larchf'd	·03	1
Corn .	Redruth, Trewirgie......	·71	20	*Glam* .	Ystalyfera, Wern Ho....	1·84	34
,, .	Penzance, Morrab Gdns.	·51	16	,, .	Treherbert, Tynywaun.	1·99	...
,, .	St. Austell, Trevarna...	·47	14	,, .	Cardiff, Penylan..........	·59	19
Soms .	Chewton Mendip.........	·38	11	*Carm* .	Carmarthen,M. & P. Sch.	1·48	37
,, .	Long Ashton............	·46	18	*Pemb* .	Pembroke,Stackpole Ct.	·47	17
,, .	Street, Millfield..........	·19	9	*Card* .	Aberystwyth	1·55	...
Glos .	Blockley	·49	...	*Rad* .	BirmW.W.Tyrmynydd	1·19	22
,, .	Cirencester, Gwynfa....	·24	10	*Mont* .	Newtown, Penarth Weir	...	...
Here .	Ross-on-Wye..............	·02	1	,,	Lake Vyrnwy	1·86	43
Salop.	Church Stretton.........	·37	16	*Flint* .	Sealand Aerodrome......	·70	40
,, .	Shifnal, Hatton Grange	·44	24	*Mer* .	Blaenau Festiniog	7·18	92
,, .	Cheswardine Hall........	·69	33	,, .	Dolgelley, Bontddu......	3·39	69
Worc .	Malvern, Free Library...	·21	11	*Carn* .	Llandudno	1·46	72
,, .	Ombersley, Holt Lock.	·27	16	,, .	Snowdon, L. Llydaw 9..	12·90	...
War .	Alcester, Ragley Hall...	·33	19	*Ang* .	Holyhead, Salt Island...	1·45	55
,, .	Birminghm, Edgbaston	·44	23	,, .	Lligwy	2·48	...

Rainfall : March, 1938 : Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	1·88	63	*R&C* .	Achnashellach	16·58	231
Guern.	St.Peter P't.Grange Rd.	·48	19	,, .	Stornoway,C.GuardStn.	4·32	111
Wig .	Pt. William, Monreith.	1·11	39	*Suth* .	Lairg......................	4·72	152
,, .	New Luce School.........	1·32	37	,, .	Skerray Borgie...........	3·58	...
Kirk .	Dalry, Glendarroch......	2·81	62	,, .	Melvich....................	3·44	121
Dumf.	Dumfries, Crichton R.I.	1·91	68	,, .	Loch More, Achfary....	16·81	261
,, .	Eskdalemuir Obs........	3·86	79	*Caith* .	Wick	2·11	93
Roxb .	Hawick, Wolfelee........	1·26	38	*Ork* .	Deerness	3·07	109
Peeb .	Stobo Castle..............	1·52	52	*Shet* .	Lerwick Observatory...	3·99	126
Berw .	Marchmont House......	·74	28	*Cork* .	Cork, University Coll...	1·52	51
E.Lot .	North Berwick Res.....	·41	22	,, .	Roches Point, C.G. Stn.	1·09	36
Midl .	Edinburgh, Blackfd. H.	·57	29	,, .	Mallow, Longueville....	1·28	44
Lan .	Auchtyfardle	2·60	...	*Kerry*.	Valentia Observatory...	2·98	66
Ayr .	Kilmarnock, Kay Park	3·65	...	,, .	Gearhameen..............	7·60	94
,, .	Girvan, Pinmore.........	2·41	64	,, .	Bally McElligott Rec...	1·75	...
,, .	Glen Afton, Ayr San. ...	4·22	100	,, .	Darrynane Abbey.......	2·10	51
Renf .	Glasgow, Queen's Park	3·63	139	*Wat* .	Waterford, Gortmore...	·80	29
,, .	Greenock, Prospect H..	6·62	142	*Tip* .	Nenagh, Castle Lough.	1·85	60
Bute .	Rothesay, Ardencraig...	3·82	106	,, .	Cashel, Ballinamona....	1·84	68
,, .	Dougarie Lodge..........	3·89	111	*Lim* .	Foynes, Coolnanes......	2·24	76
Arg .	Loch Sunart, G'dale....	8·15	147	*Clare* .	Inagh, Mount Callan....	5·48	...
,, .	Ardgour House..........	23·88	...	*Wexf* .	Gorey, Courtown Ho...	·87	38
,, .	Glen Etive.................	25·07	317	*Wick* .	Rathnew, Clonmannon.	·70	...
,, .	Oban........................	9·63	...	*Carl* .	Bagnalstown,Fenagh H.	·88	36
,, .	Poltalloch..................	6·87	179	,, .	Hacketstown Rectory...	·94	34
,, .	Inveraray Castle.........	15·12	238	*Leix* .	Blandsfort House.......	1·48	56
,, .	Islay, Eallabus...........	3·45	90	*Offaly*.	Birr Castle................	1·35	56
,, .	Mull, Benmore...........	16·40	155	*Kild* .	Straffan House..........	1·47	63
,, .	Tiree	4·30	128	*Dublin*	Dublin, Phoenix Park..	·85	44
Kinr .	Loch Leven Sluice.......	1·25	43	,, .	Balbriggan, Ardgillan...	·68	34
Fife .	Leuchars Aerodrome...	·48	25	*Meath*.	Kells, Headfort..........	·71	26
Perth .	Loch Dhu..................	8·20	124	*W.M* .	Moate, Coolatore.........	1·18	...
,, .	Crieff, Strathearn Hyd.	1·54	48	,, .	Mullingar, Belvedere...	1·57	58
,, .	Blair Castle Gardens....	1·51	58	*Long* .	Castle Forbes Gdns......	2·19	74
Angus.	Kettins School............	·36	15	*Gal* .	Galway, Grammar Sch.	3·89	113
,, .	Pearsie House............	·71	...	,, .	Ballynahinch Castle....	4·99	97
,, .	Montrose, Sunnyside...	·33	16	,, .	Ahascragh, Clonbrock.	2·41	72
Aber .	Balmoral Castle Gdns..	·47	16	*Rosc* .	Strokestown, C'node.....	2·52	91
,, .	Logie Coldstone Sch....	·48	18	*Mayo*.	Blacksod Point..........	3·35	82
,, .	Aberdeen Observatory.	·51	21	,, .	Mallaranny	4·42	...
,, .	New Deer School House	·99	38	,, .	Westport House.........	1·64	42
Moray	Gordon Castle...........	·97	42	,, .	Delphi Lodge.............	9·57	115
,, .	Grantown-on-Spey	...	...	*Sligo* .	Markree Castle...........	2·32	67
Nairn.	Nairn	1·02	55	*Cavan*.	Crossdoney, Kevit Cas..	1·46	...
Inv's .	Ben Alder Lodge.........	7·38	...	*Ferm* .	Crom Castle..............	2·32	75
,, .	Kingussie, The Birches.	2·47	...	*Arm* .	Armagh Obsy............	1·00	43
,, .	Loch Ness, Foyers	3·79	118	*Down*.	Fofanny Reservoir......	2·14	...
,, .	Inverness, Culduthel R.	1·42	65	,, .	Seaforde	·99	34
,, .	Loch Quoich, Loan......	50·03	...	,, .	Donaghadee, C. G. Stn.	·80	36
,, .	Glenquoich................	32·02	329	*Antr* .	Belfast,Queen's Univ....	1·17	46
,, .	Arisaig House............	10·35	221	,, .	Aldergrove Aerodrome.	1·21	48
,, .	Glenleven, Corrour......	13·32	229	,, .	Ballymena, Harryville.	3·30	105
,, .	Fort William, Glasdrum	16·12	...	*Lon* .	Garvagh, Moneydig....	2·19	...
,, .	Skye, Dunvegan.........	9·68	...	,, .	Londonderry, Creggan.	2·61	82
,, .	Barra, Skallary..........	4·65	...	*Tyr* .	Omagh, Edenfel.........	2·33	74
R&C.	Tain, Ardlarach.........	1·12	45	*Don* .	Malin Head...............	2·33	81
,, .	Ullapool	7·44	178	,,	Dunkineely...............	2·20	...

Climatological Table for the British Empire, October, 1937

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean.							
	Mean of Day M.S.L.	Diff. from Normal.	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.			Am'nt.	Diff. from Normal.	Days.	Hours per day.	Percentage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy....	1015·0	+ 1·0	67	37	58·3	46·6	52·5	+ 1·6	48·2	91	8·6	2·37	− 0·33	10	2·6	25
Gibraltar	1013·8	− 3·4	76	53	67·1	60·1	63·6	− 2·8	60·3	90	7·8	10·80	...	19	...	...
Malta....................	1016·1	+ 0·1	87	53	75·7	67·1	71·4	+ 0·5	66·0	77	6·0	1·88	− 0·99	5	6·6	58
St. Helena	1014·9	− 0·4	65	54	60·5	54·4	57·5	0·0	55·3	93	10·0	1·87	+ 0·56	14	...	...
Freetown, Sierra Leone	1012·3	+ 2·4	88	68	85·0	72·2	78·6	...	74·7	83	5·6	7·60	− 5·02	22	...	...
Lagos, Nigeria	1012·1	+ 1·1	87	71	85·1	73·9	79·5	− 0·2	75·4	87	8·2	5·45	− 2·32	16	5·7	48
Kaduna, Nigeria	1011·3	...	92	63	88·3	67·3	77·8	+ 1·5	71·5	86	7·9	2·29	− 0·46	8	7·5	63
Zomba, Nyasaland	1012·5	+ 1·7	91	54	82·9	61·7	72·3	− 1·8	68·7	79	3·5	1·32	− 0·20	2	...	...
Salisbury, Rhodesia...	1012·7	+ 0·5	93	47	82·9	56·8	69·9	− 0·8	56·3	37	2·5	0·07	...	2	9·2	74
Cape Town	1017·9	+ 0·5	94	43	72·6	53·2	62·9	+ 1·7	55·0	72	6·1	1·12	− 0·53	10	...	...
Johannesburg	1014·1	+ 1·2	86	40	75·7	52·4	64·1	+ 1·3	52·6	49	3·5	1·35	− 1·21	7	9·0	71
Mauritius	1018·1	− 0·1	85	59	79·9	64·9	72·4	− 0·3	...	...	5·6	2·14	+ 0·47	14	8·8	70
Calcutta, Alipore Obsy.	1010·2	+ 0·8	91	67	88·1	74·4	81·3	+ 2·0	75·7	85	4·2	7·89	+ 2·99	7*	...	...
Bombay	1009·8	0·0	92	72	88·7	76·0	82·3	− 0·1	75·9	81	3·1	1·77	+ 0·10	3*	...	...
Madras	1009·3	+ 0·4	94	71	87·4	75·0	81·2	− 1·1	76·6	86	6·7	10·40	− 0·75	14*	...	...
Colombo, Ceylon	1011·2	+ 1·2	87	72	85·0	75·2	80·1	− 0·4	77·0	78	6·3	9·67	− 3·69	19	7·8	65
Singapore...............	1010·6	+ 0·9	88	72	85·3	75·4	80·3	− 0·8	77·3	81	7·6	3·54	− 4·53	18	4·9	40
Hongkong...............	1013·8	+ 0·1	89	62	82·5	73·5	78·0	+ 1·1	71·2	65	3·7	1·50	− 3·44	8	8·6	75
Sandakan	1009·3	...	91	72	88·5	74·9	81·7	+ 0·3	77·4	83	8·6	11·55	+ 1·22	18	...	...
Sydney, N.S.W..........	1015·7	+ 0·9	87	52	69·5	58·3	63·9	+ 0·3	59·0	65	7·5	3·31	+ 0·46	17	5·4	42
Melbourne	1016·3	+ 1·5	84	44	68·4	50·6	59·5	+ 1·8	54·5	64	6·8	6·09	+ 3·46	14	5·3	47
Adelaide.................	1017·6	+ 1·6	94	44	73·3	53·0	63·1	+ 1·2	55·6	52	6·2	0·54	− 1·20	8	6·7	52
Perth, W. Australia ...	1017·4	+ 0·6	91	45	71·5	53·5	62·5	+ 1·7	56·3	56	5·9	1·48	− 0·74	12	8·5	66
Coolgardie	1015·5	+ 0·6	100	41	80·8	53·8	67·3	+ 3·6	56·7	49	2·9	0·15	− 0·51	2	...	...
Brisbane.................	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hobart, Tasmania......	1016·1	+ 5·8	75	38	63·0	48·0	55·5	+ 1·4	50·3	64	6·8	2·63	+ 0·37	17	6·1	46
Wellington, N.Z.	1021·8	+ 8·7	65	38	58·7	44·4	51·5	− 2·9	48·9	69	5·5	0·94	− 3·14	7	8·2	62
Suva, Fiji	1013·8	+ 0·6	89	66	81·6	72·2	76·9	+ 1·1	72·6	81	7·3	6·63	− 1·66	21	4·6	37
Apia, Samoa	1011·4	− 0·1	87	72	85·0	74·6	79·8	+ 1·4	76·7	76	5·3	9·28	+ 2·90	18	6·6	53
Kingston, Jamaica	1011·2	− 0·3	92	71	87·8	73·6	80·7	+ 0·2	72·6	87	3·8	5·39	− 2·07	15	8·2	69
Grenada, W.I.	1010·4	− 0·4	89	71	87	73	80	− 0·1	74	75	4	15·22	+ 7·46	25	...	...
Toronto..................	1015·9	− 1·6	78	28	63·8	41·2	47·5	− 1·1	42·7	83	8·1	2·73	+ 0·16	10	3·4	31
Winnipeg	1015·9	+ 1·0	70	20	49·0	32·9	40·9	+ 0·2	34·7	80	7·5	0·71	− 0·66	8	3·2	30
St. John, N.B.	1016·6	+ 0·8	64	30	54·0	41·4	47·7	+ 2·4	43·4	82	6·4	4·72	+ 0·18	16	4·2	38
Victoria, B.C...........	1016·8	− 0·3	68	42	60·1	47·4	53·7	+ 3·4	51·4	92	6·7	3·11	+ 0·54	13	4·9	45

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THE DROUGHT, FEBRUARY TO APRIL, 1938

The drought of the spring of this year has been acclaimed in the newspaper press as unequalled for over a century. Although it is a little too early to make a detailed study of the drought, there is no doubt at all that over a very wide area the aggregate shortage of rainfall during the three months ending in April was unprecedented within living memory.

Table I shows the general rainfall over the whole of the British Isles for the separate months of February, March and April and for the total period in 1938 and in some previous years of drought, while Table II gives the equivalent figures for England and Wales as this is the area most affected. The percentage of the average rainfall (1881–1915) is also given in these tables.

Looking at the figures in Table II we see that in England and Wales the combined rainfall of February and March, 1938 was distinctly greater than the combined rainfall of those months in 1929; also the combined rainfall of March and April, 1938 was rather greater than the combined rainfall of those months in 1893. The aggregate for the three months, amounting this year to only 2·34 inches or 32 per cent. of the average, is however very much less than that of any similar period since comparable records began in 1870. In carrying the comparison back to earlier years we have also used the table of monthly rainfall percentages given by J. Glasspoole and Miss F. J. Nicholas.(1) From this article, where it is explained that the values for years before 1870 are unavoidably less precise, we see that noteworthy sequences of three dry months February to April, occurred in 1887, 1875, 1863, 1854, 1834, 1790, 1786, 1785, 1771, 1741, 1740 and 1738. In 1785 the percentage was 44 in February, 17 in March and 22 in April and we may estimate that the total general rainfall over England and Wales for the three months was about 2·1 inch. With this exception no other similar period appears to have given a total lower than that experienced in 1938.

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(1) General Monthly Rainfall over England and Wales 1727–1931—*British Rainfall*, 1931, p. 299.

TABLE I. GENERAL RAINFALL OVER THE BRITISH ISLES

Year.	February.		March.		April.		Feb.–April.	
	in.	%	in.	%	in.	%	in.	%
Av. 1881–1915 ...	3·26	100	3·22	100	2·52	100	9·00	100
1893	4·79	147	1·09	34	0·88	35	7·76	86
1921	0·98	30	3·45	107	1·46	58	5·89	65
1929	2·09	64	0·61	19	1·59	63	4·29	48
1938	2·02	62	1·67	52	0·43	16	4·12	45

TABLE II. GENERAL RAINFALL OVER ENGLAND AND WALES

Year.	February.		March.		April.		Feb.–April.	
	in.	%	in.	%	in.	%	in.	%
Av. 1881–1915 ...	2·57	100	2·67	100	2·12	100	7·36	100
1893	4·26	166	0·61	23	0·38	18	5·25	71
1921	0·39	15	1·95	73	1·34	63	3·68	50
1929	1·23	48	0·37	14	1·29	61	2·89	39
1938	1·34	52	0·72	27	0·28	13	2·34	32

Reference to the same table shows that a general rainfall over England and Wales of less than 20 per cent. of the average in April has occurred on only three previous occasions namely in 1817 (16 per cent.), 1893 (18 per cent.) and 1912 (15 per cent.). During the great spring drought of 1893 no rain at all occurred during April over a considerable part of south-east England. Also in April, 1912, no rain occurred in parts of Berkshire and Sussex. During April, 1938, only a few stations recorded no measurable rain ; the main feature was the large area with only a total of about one-tenth of an inch. The small totals were perhaps most remarkable over Ireland where the general rainfall was ·20 inch (or 7 per cent. of the average), the next driest Aprils being those of 1875 and 1921 with 43 and 45 per cent. respectively. Falls of 1 in. or more were restricted to mountainous districts of central and northern Wales, Derbyshire, the English Lake District and parts of the north and west of Scotland. The month certainly ranks with February, 1891, June, 1925 and February, 1932, as one of the driest ever recorded over the British Isles generally.

The following is a brief summary of the dry periods during the three months under review. The first seven days and the 18th to 23rd of February were dry generally over the whole of England and Wales, while the driest days over Scotland and Ireland were from the 12th to 23rd. The last few days of the month were wet over the whole of the British Isles except at a few individual stations. With the 1st of March the drought began again over England, Wales and south-eastern Scotland, and except for the few days 24th–27th, continued throughout the month. The rest of Scotland experienced a few dry days about the 11th while over Ireland the periods of general dryness were from the 2nd to 7th and from the 10th to 13th. Except for partial breaks on the 2nd and 22nd of April the weather continued dry over England, Wales and south-eastern Scotland throughout the month, the last two days of the month producing showers of rain, hail and sleet over the east coast from Tynemouth to Shoeburyness. The whole of Ireland had very little rain from April 5th, while western and south-western Scotland had dry weather from the 7th, except for a break on the 21st and 22nd. The remaining parts of Scotland also experienced dry weather about the second week in April but it was broken in most parts on the 15th. The days on which no measurable rain fell at any of the representative stations in the *Daily Weather Report* are of interest ; they are as follows :— February 20th, March 12th, April 8th and 10th to 14th. Periods when very little rain fell in all districts were February 17th to 23rd, March 12th to 13th and April 8th to 14th.

The famous spring drought of 1893 did not commence until the beginning of March and persisted until the first few days of July. At North Ockendon, Romford, Essex, only 1·23 in. of rain was recorded on the 128 days from March 2nd to July 7th and at Dungeness in Kent 1·27 in. was measured in the 127 days from February 27th to July 3rd. These were the longest partial droughts observed, but over 100 days of partial drought were also recorded at stations in south-eastern England, and all stations south of a line from Bristol to Boston in Lincolnshire had a partial drought exceeding 75 days. So far this year we find that in the 89 days from February 1st to April 30th, Kew Observatory recorded 0·70 in. of rain, Ross-on-Wye 0·76 in., and South Farnborough 0·79 in. Many stations have recorded about 60 days of partial drought beginning 1st March. Perhaps the best illustration of the severity of the 1893 drought is the example quoted by G. J. Symons in his article in the *Journal of the Royal Agricultural Society*, June, 1893, where he mentions that a station in Brighton recorded two " absolute droughts ", of 30 days and 28 days respectively, which were only separated by one day on which 0·06 in. fell during a shower of rain, so that the rainfall for the whole of the 59 days was only 0·06 in. Ross-on-Wye has experienced almost a similar period this year, for March was almost entirely dry and April gave rain only on the 2nd and 21st, and in the 61 days from March 1st to April 20th, only 0·06 in. was measured.

Some Notes on the April Anticyclone

Persistent anticyclones always pass through a succession of cycles, and that of April, 1938 was no exception, being rejuvenated four times during the month, through fresh developments in the rear of cold fronts, or occlusions with colder air behind them. These fronts can be traced across the Atlantic and finally crossed the British Isles from north to south, dying out in the process. In the course of the first rejuvenation (April 7th to 9th) a cold wedge of high pressure to north of the old anticyclone developed into a new system of unusual intensity for April. The second and fourth rejuvenations (15th to 16th and 26th to 27th) were both due to a distinct new anticyclone moving eastward on the Atlantic and absorbing the old decaying one. In the third case (24th) the new system amalgamated with the old one, with a rapidly vanishing front moving through the complex central area. In the course of these developments the air in the lower troposphere was renewed three times over the greater part of the anticyclonic area, and on another occasion over at least half of it.

After the evening of April 16th, the air supply over England was continuously drawn from high latitudes, mainly from northern Canada. After reaching the Iceland area it circulated round the anticyclone, and supplied the N.E. current over southern England. The following figures for the upper air temperature for the second half of the month show the result of the cold air supply :—

Pressure ...	900 mb.	800 mb.	700 mb.	600 mb.	500 mb.
	° F.	° F.	° F.	° F.	° F.
Mildenhall Mean temp.	34·4 (−3·6)	21·5 (−6·9)	13·9 (−5·4)	1·9 (−3·7)	−11·7 (−1·7)
Aldergrove Mean temp.	36·2	29·1	22·0	10·0	−5·4

The figures in the brackets are the departures from the averages for the second half of April, deduced from the April and May figures. No averages are available for Aldergrove, but it is clear that from 800 mb. upwards temperature exceeded the normal in that area owing to subsidence. The air over south-east England had also almost certainly subsided, but not sufficiently to overcome its initial coldness. At 900 mb. the deficiency of temperature had evidently been reduced by heating from below during the long sea track. The natural results of the Mildenhall distribution of upper air temperature over the land were cool mainly cloudy days and clear frosty nights.

The NE. current which crossed southern England continued its circulation round the anticyclone, becoming an east to south-east wind. Beyond 30° W. the pressure distribution and the corresponding air trajectories were variable, but at times the air curved round to become a south-west current and completed the circuit of the anticyclone. This air was now relatively warm, and it became occluded soon after completing the circuit, but some of it reached Scotland about April 20th to 21st, 25th and 27th, before being finally occluded.

The cirrus cloud motion over England was from west to north-west on 17th and 18th, but afterwards was north to north-east. The vertical extent of the anticyclone thereby indicated was typical, but this does not imply that the anticyclone can be explained by the persistence of a definite mass of cold air in the stratosphere. We have seen that in the lower troposphere, where the pressure distribution varied rather less than it did high up, judging from the cirrus motion, the air was very largely renewed four times. When an anticyclone is rejuvenated without the prior existence of a complete new centre, the renewal of the air is associated with the subsidence and lateral divergence of the new cold air, involving a component of wind across the isobars, with some ascent of the warmed air of the old anticyclone, and with associated irregularities in the isobaric distribution. Corresponding developments in the upper troposphere would be convergence over subsiding air, divergence over ascending air, and irregularities of the isobars. Such processes could renew the air high up as readily as the complementary processes undoubtedly do low down. If the air movements in question vanish at some level in the stratosphere, it only means that the layer in question is inactive. It is just as logical to regard pressure changes high up as due to air movements underneath as to take the opposite view. In all probability the persistent feature is a system of organisation of air movement, rather than any one mass of air.

Stratospheric theories fail to account for the fact that persistent anticyclones are very limited in their geographical distribution. The region off our west and north-west coasts is a favourite one both for stationary depressions and anticyclones. Probably the weak gradient of sea temperature is an important feature. There is also a seasonal influence, persistent anticyclones off our north-west coasts being most frequent in spring. Considering the conditions in February, 1932,[1] and also the low continental temperatures in April, 1938, the explanation can hardly be continental heating. A possible reason is the plentiful supply of cold air at that season, and the poor supply of warm air, owing to the low sea temperature. The effect of sea temperature on an anticyclone is most likely to be indirect, the direct influence being the deepening of depressions. When active depressions are at all frequent the anticyclone tends to be kept well to southwards, and may even be absent over the greater part of the Atlantic. Once an anticyclone is established, a breakdown of vertical stability is very unlikely, even if the sea temperature is high, since subsidence exerts a very powerful stabilising influence. Even over land in mid-summer, thunderstorms in anticyclones only develop over high ground, or where a pool of warm air has formed a shallow depression within the high pressure area, with local convergence instead of divergence.

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[1] See *Meteorological Magazine* 67, 1932, p. 29.

C. K. M. DOUGLAS.

The Horsey Floods of February, 1938

Current and wind at the time as observed aboard certain Lightvessels

BY J. N. CARRUTHERS, D.SC., F.INST.P. (Fisheries Laboratory, Lowestoft).

On the evening of Saturday, February 12th, 1938, the sea burst over the low-lying coastland between Winterton and Palling in Norfolk and flooded an area of farms and marshes given in one estimate as about 15 square miles. Full accounts of the damage done at various places are of course readily accessible in the newspapers of the time.

On Sunday, April 3rd of this year, the sea broke through defences which had been recently constructed at Horsey, and swirled inland far enough to menace the edges of the remaining sandhills.

In view of these events considerable interest attaches to the contemporaneous records of current and wind from a number of lightvessels which are filed at the Lowestoft Fisheries Laboratory. With the permission of the Elder Brethren of Trinity House, and for application to problems of fishery research, continuous observations upon the water-flow past various English lightships are made on behalf of the Ministry of Agriculture and Fisheries by the officers and crew. The observers employ a very robust current-measuring instrument specially designed in Lowestoft for the purpose, and they need never stop observing however bad the weather or silty the water. At the time of the Horsey flooding, one of the instruments in question was in use from each of the six following lightvessels :—

(1) The Cromer Knoll lightship moored at a point about 20 miles north of Cromer.

(2) The Galloper lightship lying 25 miles off Orford Ness in a direction approximately south-east.

(3) The Sandettié lightvessel situated 18 miles east of Deal and 16 miles north of Calais.

(4) The Maas lightship lying about 8½ miles off the Hook of Holland in a direction about north-west.

(5) The Horns Rev lightvessel moored 25 miles west of Blaavand Point (Jutland) in the latitude of the Farn Islands.

(6) The Royal Sovereign lightship about 7½ miles off Beachy Head and roughly south of Bexhill.

The positions of the lightvessels can be seen from the accompanying small chart.

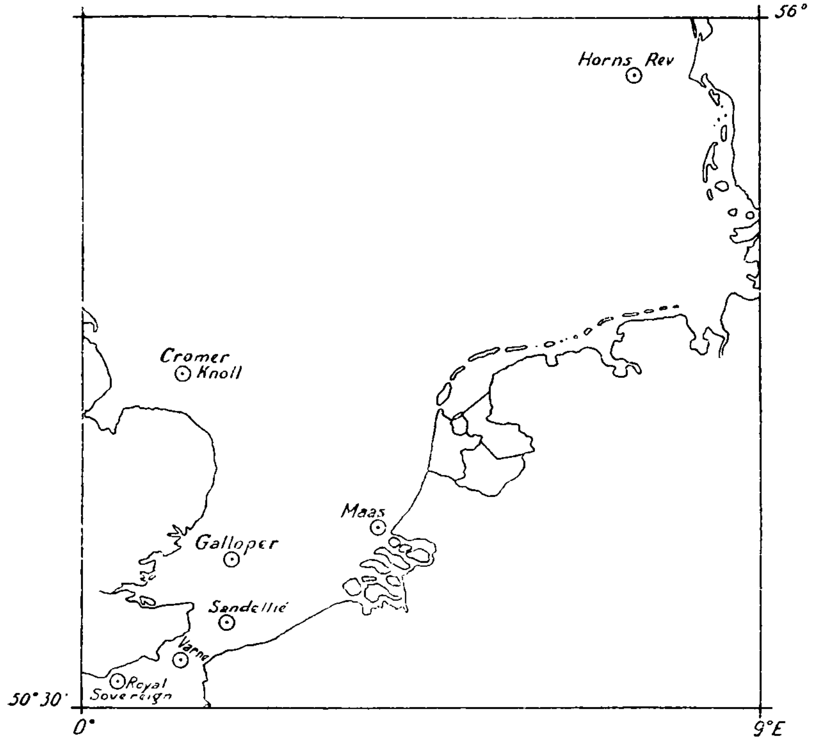

FIG. 1.—CHART SHOWING THE POSITIONS OF THE SEVEN LIGHTVESSELS ENGAGED IN CONTINUOUS CURRENT MEASURING.

At each of the lightships the observing went on without intermission, and in the case of the French vessel the work was done for the Lowestoft Laboratory by arrangement with the Office Scientifique et Technique des Pêches Maritimes. The observations aboard the Dutch lightship were part of a comprehensive scheme recently launched by the Rijkswaterstaat who keep very careful watch upon the vagaries of the currents and the changes in the sands in the interests of their coast. At the Horns Rev lightship a parallel programme to the English one was being carried out by the Danish Marinbiologisk Laboratorium of Charlottenlund. Copies of the Dutch and Danish records were kindly supplied to the writer who here expresses his thanks to Dr. J. van Veen and Dr. Å. V. Tåning, respectively.

At a very important key observing position—the Varne lightvessel which is situated in Dover Straits about half-way between Hythe and Gris Nez—continuous current observations were being made by means of another instrument also designed at and supplied by the Lowestoft Laboratory. The work there had been in train for about 12 years.

Records of Wind Conditions

From the English lightvessels and from the French one also, eight observations of wind *per* day are available ; at the Horns Rev six *per* day were logged, whilst at the Maas lightship, twenty-four observations were recorded each day. Aboard all the ships the wind observations were personal ones, and except at the French vessel strength was estimated according to the Beaufort Scale of ten numbers. At the Sandettié, wind strength was logged according to a scale of six numbers in use by French seamen. In the interests of brevity, vector-averages have been worked out for use here. The wind strengths were converted into miles per hour and dealt with in such a manner as to yield for each day, a figure and direction implying what constant wind would (more or less) have effected the same air transport as did all the varying winds which actually blew. It is best to have wind data in this form when it is intended to consider the inter-relationship between wind and current.

In the case of the Sandettié lightvessel, the wind speeds should not be regarded as comparable with those relating to the other positions. The wind data are set down in Table 1.

TABLE 1—WINDS AT THE VARIOUS LIGHTVESSELS

(The Entries are Vector-Averages as explained in the Text. They are based upon (n) observations and are expressed in miles per hour from a true direction.

Ship.	Thursday, 10.2.38.	Friday, 11.2.38.	Saturday, 12.2.38.	Sunday, 13.2.38.
Cromer Knoll	21·6 N.57° W. (8)	25·6 N.36° W. (8)	32·8 N.38° W. (8)	32·8 N.11° E. (8)
Galloper ...	22·8 N.72° W. (8)	28·6 N.40° W. (8)	32·9 N.40° W. (8)	39·2 N. 3° E. (8)
Sandettié*	25·1 Due W. (8)	42·2 N.37° W. (8)	31·5 N.27° W. (8)	49·0 N.10° E. (8)
Maas ...		34·7 N. 2° W. (24)	24·6 N.25° W. (24)	
Horns Rev		37·9 N.20° W. (6)	11·2 N.22° E. (6)	
Varne ...	17·7 N.87°W. (8)	22·6 N. 8° W. (8)	25·8 N.32° W. (8)	33·8 N.26° W. (8)
Royal Sovereign	19·3 S.88° W. (8)	17·2 N. 3° E. (8)	27·6 N.27° W. (8)	33·6 N.34° E. (8)

* See Reservation in Text.

The Flooding

As is quite well known, the flooding was due to a pronounced and wind-induced deepening of the waters of the southern North Sea at a time when the tide would have been high if not affected meteorologically. An already high water-level was markedly raised by strong winds from the NW. quadrant. Relief from such a pooling-up (if the wind remains strong and in the NW.) can apparently come only from an escape of water through the Straits of Dover down Channel, and it is known that there is usually a flow of water *from* the English Channel into the North Sea as attested by the long series of records already referred to.

The writer's justification for concerning himself with this question of flooding is that he has data which show what was happening to the tidal streams at the time, over a considerable area. It is thought that there can never before have been available information of the kind set down below concerning the actual water movements in the open sea at a time when the waters of the Southern Bight were being markedly deepened as the result of wind influence. It is a feature of the instrument which provided our data that its showings are just as acceptable under the very rough sea conditions which prevailed on February 12th, 1938 as they are at times of calm weather.

Although it is horizontal water movements which are our concern here, some remarks upon the deepening with which the profoundly modified tidal streams were associated are necessary to convey an impression of its scale.

It is to be borne in mind that the Horsey flooding took place about 48 hours before full moon, and that the highest predicted water-level was not due until the night tide of Wednesday, February 16th—that is, until the eighth high tide following. The prediction for Dover (read from the " Admiralty Tide Tables ") for the high water of Saturday night, February 12th, was 17·2 ft, whereas that for midnight on the following Wednesday was 20·0 ft. It is very fortunate therefore that the north-westerly gale, which was responsible for the flooding, died away when it did.

A glance at the right-hand column of Table 1 will show that on Sunday, February 13th, the winds were predominantly from east of north. Actually they had veered from north-west in the evening of Saturday according to the Cromer Knoll records, and after staying a few hours in the north had further veered to north-north-east. In this quarter they stayed over Sunday. For the next three days the wind was mostly easterly, and it stayed between east and north-east until Monday, February 21st.

We may mention a few details regarding the water deepening due to the north-westerly gale. The night tide of the critical Saturday reached a level at Dover just over 5 ft. in excess of prediction, and the preceding low tide stood at about 2 ft. above predicted level. At Southend the excess was nearly 6 ft. for the night high-water and very nearly 2½ ft. for the preceding low-water. The high-water crest at Southend was even an inch or so above that of January 6th/7th, 1928. Across at the Hook of Holland, the midnight high tide of Saturday, February 12th had stood at a level 6½ ft. above prediction, and the preceding second low-water (3 hours earlier) had stood at 2 ft. 9 in. above. The excesses for the preceding intermediate high, first low, and high waters, were 4 ft. 6 in., 1 ft. 9 in., and 5 ft. 9 in., respectively. At Harwich the night high and afternoon low tides of Saturday, February 12th, were respectively 5·3 ft. and 2·1 ft. above prediction—the corresponding figures for Sheerness being 6·6 ft. and 2·1 ft.

The Water Movements

The water movements past the various lightvessels were first worked up into the form of overall set, but it has been thought preferable to restrict attention here to tidal streamings for the good reason that comparison can then be more effectively made with well-based means. Also, the modifications brought about by the meteorological conditions can be more easily appreciated.

All that is necessary here is brief comment on Table 2 wherein the relevant data are set down.

The entries for Cromer Knoll and Galloper in Table 2 show quite impressively how the waters of the North Sea were being urged to the southward down the coast of East Anglia. At the Sandettié, instead of a water transport towards north-east at the rate of some 1½ miles a day, there was a transport in the opposite direction approaching 15½ miles a day in amount. At the Maas, the usual north-easterly flow of about 1¾ miles a day on the average had given place to a reversed flow of about 7 miles a day. Even at the Horns Rev the usual NNW.-going flow had been stopped and was soon succeeded by a flow towards the opposite direction.

These facts betoken an enormous urge of water into the Straits of Dover.

At the Varne lightship there was no record of current relating to the day of chief interest only; there the flow is measured at the depth of six fathoms* and we have a record for a four-day period centred at 2045 on February 11th. During that time the flow was 7·9 sea-miles a day towards S. 47° W. true. Over the previous four days it had been towards N. 24° E. and at the rate of 6·4 sea-miles a day. It is clear therefore that the pooling-up of the Southern Bight was being relieved by an escape of water into the Channel at a considerable rate, and some idea of the extent of this can be gained from the fact that the flow at the Royal Sovereign was reversed at the time. In the absence of the information from the Horns Rev lightvessel, one might have supposed that the situation could have

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* At the Maas lightship the observations were made at a depth of about 4½ fathoms, and at the other lightvessels the measurements were made at about 1½ fathoms depth.

TABLE 2—SHOWING (UNDER A AND B) THE DAILY RUN IN SEA-MILES OF THE FLOOD AND EBB STREAMS AT THE VARIOUS LIGHTVESSELS AT THE TIME OF THE HORSEY FLOODING OF FEBRUARY, 1938 (NUMERATORS) COMPARED WITH AVERAGE VALUES (DENOMINATORS) AND (UNDER C), THE CORRESPONDING EXCESSES. EACH UPPER ENTRY REFERS TO THE ONE DAY INDICATED. THIS, WITH ITS CENTRAL TIME IS SHOWN BENEATH THE FIRST OF THE "FRACTIONS."

Ship.	A {Flood Streams towards	B {Ebb Streams towards	C {Excess towards	Basis of Means used for Comparison.	Remarks as to Preceding and/or Following Day or Days.
Cromer Knoll ...	SE. 11·3 10·4 12.2.38—1515	NW. 6·5 9·9	SE. 4·8 SE. 0·5	Average for the Whole Year 1937.	
Galloper	SW. 14·8 12·3 12.2.38—0645	NE. 10·6 11·0	SW. 4·2 SW. 1·3	Average for the last three Entire Winters.	*Preceding Day*— SW. excess was 9·8 miles. *Following Day*— SW. excess was 12·1 miles.
Sandettié ...	NE. 4·9 13·2 12.2.38—2345	SW. 20·3 11·6	SW. 15·4 NE. 1·6	Average for the last three Entire Winters.	
Maas	N.71° E. 6·6* N.52° E. 9·8 12.2.38	S.50° W. 13·6* S.58° W. 8·1	*ca.* SW. 7·0* *ca.* NE.'E. 1·7	Average for period July, 1937, to February, 1938, inclusive.	*Preceding Day*— Flood *ca.* 1·1 miles.† Ebb *ca.* 13·1 miles.† Excess—about 12 miles towards SW. approx.
Horns Rev ...	NNW. 5·0 7·6 12.2.38—0955	SSE. 4·9 4·2	NNW. 0·1‡ NNW. 3·4	Average for Winter 1937/38 = Dec., 1937 + Jan., 1938 + Feb., 1938.	*Following 3 days*— SSE. excess was 3·7, 5·0, and 6·8 miles respectively.
Royal Sovereign	E. 6·8 9·6 12.2.38—0845	SW. 9·2 8·0	SW. 2·4 E. 1·6	Average for the Whole Year 1937.	*Preceding Day*— SW. excess was 3·1 miles. *Following Day*— SW. excess was 6·5 miles.

* The observing technique is somewhat different at this ship. These values were obtained by vector-averaging 22 equally-spaced observations of current within the day.

† These values were obtained on vector-averaging 23 equally-spaced observations of current made on February 11th. The flood stream ran mainly towards a N. by E.'ly point and the ebb towards a WSW.'ly point.

‡ The least amount of drift at this vessel during the whole Winter.

been somewhat relieved by a strengthening of the usual north-going flow up the east side of the southern North Sea. Actually, the flow was to the southward there for some days afterwards.

The fact that such a reversal of flow in the eastern Channel as occurred at the critical time in February 1938, persisted on such a scale as it did on the following days, must, with the disappearance of north-westerly winds over the North Sea, have relieved the situation quickly. Had the winds stayed in the north-west and remained strong, there must have occurred still more disastrous flooding in Norfolk. That such would have been the case seems certain because there were still more than a dozen higher tides to be expected. If therefore, at high tide time a few days later, there had been a *sudden* increase in strength of an already strong wind which had been blowing persistently from the danger quarter, very much more serious trouble on the Norfolk coast would clearly have been inevitable. The quick surge which would have resulted, would have met with greater resistance than a few days earlier, so that, where the North Sea starts to narrow, deplorable consequences would have ensued.

A few words on the events of Sunday, April 3rd and succeeding days—though lightvessel records of current and wind are not available at the time of writing.* Here the break-through occurred at the time of highest expected tide. It came at the time of a tide which, judging from Dover predictions ("Admiralty Tide Tables"), was due to be 2 ft. higher than that of Saturday, February 12th. In the case of the later flooding the following tides were due to be less and less, and it would seem therefore that the associated wind conditions must have been much less potentially dangerous than in February.

Acknowledgments

For information as to actual heights of tide I am indebted to the following :—

The Hydrographic Department of the Admiralty—in the cases of Harwich and Sheerness.

Commander E. C. Shankland, R.N.R., F.R.S.E., River Superintendent, Port of London—in the case of Southend.

Mr. G. Sutton, Superintendent of Works to the Dover Harbour Board.

Dr. J. van Veen of the Rijkswaterstaat at the Hague.

APPENDIX

Since the above was written, records have been received from the Royal Sovereign lightship which show that during the day centred at 0925 on Sunday, April 3rd, there was an ebb (towards SW.) excess of $2\frac{1}{3}$ miles — whereas the previous day had witnessed a flood (towards E.) excess of $5\frac{1}{3}$ miles.

At the Varne lightvessel, a 2-day record centred at 1030 on Sunday,

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* But see Appendix.

April 3rd, shows a residual flow of 5·0 miles a day towards S. 30° W. Here the preceding and following days were both days of flow towards the most usual (NE.-going) direction.

A record from the Cromer Knoll lightship, which refers to the day centred at 0715 on Sunday, April 3rd, bears witness to a flow of 4⅓ miles towards SE. The preceding day had also been a day of SE.-going flow (2⅔ miles) but, on the following day, there was hardly any overall water movement whatsoever.

OFFICIAL PUBLICATIONS

AVERAGES OF HUMIDITY FOR THE BRITISH ISLES (M.O. 421)

This publication, which is a companion volume to Averages of Temperature (M.O. 407) and Averages of Sunshine (M.O. 408) contains monthly and annual averages of temperature, atmospheric vapour pressure and moisture content at midday (13h. G.M.T.) for 44 well-distributed stations, together with averages of relative humidity in the morning (7h.) at midday (13h.) and in the evening (18h.). Supplementary tables contain hourly averages of relative humidity and vapour pressure at selected stations. The geographical distribution of average relative humidity and vapour pressure at midday is shown by a series of twenty-six charts, covering the twelve months and the year as a whole. In an Appendix the standard values of saturation vapour pressure and the moisture content of saturated vapour are given for all temperatures from 0° F. to 120° F.

The volume thus contains much data of a kind required for engineering, industrial, medical and meteorological purposes, which has not hitherto been available in summarised form.

PROFESSIONAL NOTES

No. 80. *A height-computer for use in aerological work.* By E. G. Bilham, B.Sc., D.I.C. (M.O. 336t).

The paper describes the theory and construction of a mechanical device for determining the height of an aircraft from observations of pressure and temperature. Two forms of the instrument are described, a simple form for computation of heights up to 24,000 ft., and a more elaborate form for greater heights.

Royal Meteorological Society

The usual monthly meeting of the Society was held on April 27th, in the Society's rooms at 49, Cromwell Road, South Kensington. Dr. B. A. Keen, F.R.S., President, was in the Chair.

The following papers were read and discussed :—

A. B. Tinn.—Local temperature variations in the Nottingham district.

The author has found that considerable variations occur in the Nottingham district, though the topography offers no unusual features. An area of relatively high land, with irregular spurs, stretches north-north-east from Nottingham Castle. The monthly values of three stations for the nine years 1928–1936, and those of five other stations for shorter periods, are analysed. It is found that local differences of 10° F. in the minima may occur, and the mean monthly minima may differ by over 4° F. Although fine weather, a rising barometer, and a low humidity favour large variations, it appears that conditions producing low minima do not always give appreciable differences. Rainy, windy conditions bring the differences to a minimum. Differences of 6° F. in the maxima may occur on certain warm, sunny days in summer, and variations of 8° F. in foggy conditions. Topographical features give Attenborough the most " continental " temperatures.

E. W. Hewson, M.A., Ph.D. (Beit Scientific Research Fellow).—The application of wet-bulb potential temperature to air mass analysis, IV.

This paper describes :—(*a*) The moisture content of subsiding polar continental air over North America, under conditions when there was no likelihood of an increase in the moisture content due to precipitation from overrunning air. Two situations of this type are discussed, and no evidence is found of any appreciable increase above 850 mb. ; (*b*) the degree of homogeneity in polar continental air masses. The vertical distributions of wet-bulb potential temperature as observed nearly simultaneously at adjacent stations within an air mass are discussed in relation to their effect on the accuracy of computations of subsidence ; (*c*) the vertical velocity of air in the warm sector of a depression. It is shown that in the warm sector considered, the ascent of the air near the surface was nearly twice as rapid as that at about 600 mb. The vertical velocity of the surface air was of the order of 4 cm./sec. and that of the air at about 600 mb. was of the order of 2 cm./sec. ; (*d*) the effect of turbulence in the air near the surface. The changes of temperature and moisture content in the surface layers of a moving air mass are discussed in the light of the theory of turbulence, as developed by Richardson and Taylor.

D. Lloyd, M.Eng.—Evaporation over catchment areas.

The paper examines the variation in the annual total loss over eight drainage-areas by a statistical method. It is postulated that loss is a joint function of meteorological elements and the geological formation penetrated by any rain water ; further, that in the present stage the joint functional causation can be simplified to one of separate functions. Thus, it is assumed that the variations in loss can be associated with the rainfall, providing the opportunity for evaporation, the temperature, the sunshine experienced, and, as, following the primary loss in the zone of aeration, influent seepage may provide a flow in the zone of saturation which later may provide a deferred opportunity for evaporation from the capillary fringe and effluent seepage from ground-water, with the geological formation.

Regressions of loss on the available postulated controls have been inferred. By inductive reasoning, an equation is found approximately representing the observations over the eight areas, by which the annual loss expected on account of various influences can be estimated.

A meeting of the Society was held on Wednesday, May 4th, in the Society's rooms at 49, Cromwell Road, South Kensington. Dr. F. J. W. Whipple, F.Inst. P., Vice-President, was in the Chair, and Major H. C. Gunton, M.B.E., F.R.Ent. Soc., presented the Phenological Report for 1937.

Correspondence

To the Editor, *Meteorological Magazine*

Dust Haze in the Upper Air

At 1130 G.M.T. on October 19th, 1937, the western horizon became very hazy and by 1200 G.M.T. the haze had spread eastwards across the sky up to an angle of about 30°. During the next hour the sky became completely covered with this thin layer of dust haze. The first impression was that the haze sheet resembled a smoke haze similar to that experienced near industrial areas in the British Isles. Smoke however being more or less non-existent in this part of the world, the haze must have been due to suspended dust particles. It was very difficult to estimate the height and depth of the layer but upper winds during the forenoon of the 19th showed that up to 8,000 feet the wind was from 180° to 210° ; above that height the direction was from about 230° to 250° which is approximately the direction from which the haze appeared to be travelling. The sky was free from cloud during the period and the haze gradually disappeared towards evening.

Duststorms, associated with the circulation round the Cretian Low, were reported from the western desert on the previous days, and there seems little doubt that the dust then raised was carried along at a height somewhere in the neighbourhood of 8,000 to 12,000 feet. Warm air arrived in this area about 0600 G.M.T. on the 19th, and in the late afternoon medium and high cloud spread from west-south-west.

It would be of interest to know if this phenomenon was experienced by other stations. F. DAVIES.

Meteorological Office, Ramleh, Palestine, October 22nd, 1937.

On investigation it appears that on October 18th a well-marked cold front west of Sollum at 0600 G.M.T. was associated with a squally dust-raising wind from west, force 5. The dust was apparently carried along by the general SW. wind then prevailing over the Middle East Area. The distance from Sollum to Ramleh is about 650–700 miles and at 7,000 to 10,000 feet wind was 220° to 240°, 20–30 m.p.h., so that the dust haze should have arrived at Ramleh about 30 hours after 0600 G.M.T. on October 18th, which is exactly what happened. C. W. LAMB.

St. Elmo's Fire in Egypt

In view of Mr. Sutton's note in the March issue of the *Meteorological Magazine* the following extract from " A Search in Secret Egypt " by Paul Brunton (Rider & Co. 1936) may be of interest. A footnote to page 77 reads :*—

" Dr. Abbate Pacha, Vice-President of the Institut Egyptien spent a night in the desert near the Pyramids, together with Mr. William Groff a member of the Institut. In the official report of their experiences the latter said: ' Towards eight o'clock in the evening, I noticed a light which appeared to turn slowly around the Third Pyramid almost up to the apex ; it was like a small flame. The light made three circuits round the Pyramid and then disappeared. For a good part of the night I attentively watched the Pyramid ; towards eleven o'clock I again noticed the same light, but this time it was of a bluish colour ; it mounted slowly almost in a straight line and arrived at a certain height above the Pyramid's summit and then disappeared.' "

The account goes on to say that Mr. Groff found that this phenomenon was well-known to the Arabs who put it down to spirits. Unfortunately the weather conditions do not appear in the excerpt as cited. CICELY M. BOTLEY.

Guildables, 17, Holmesdale Gardens, Hastings, March 18th, 1938.

Persistent Fog

Referring to the article on "Persistent Fog" by Lt.-Col. E. Gold which appeared in the March, 1938 issue of the *Meteorological Magazine,* it might interest readers to learn that fog has been very prevalent this winter around Woodside Park, North London. This place lies between Barnet on the north, Mill Hill on the west and Golders Green on the south, and through this district from Barnet to Golders Green runs the Dollis Brook. The district is fairly open and there are a good many fields still left untouched by builders. On several occasions the mornings here have been very foggy but on approaching London by train via Highgate and Finsbury Park there has been an absence of fog or only a very faint mist after leaving Highgate for Finsbury Park. It has been noticed on occasions when the City of London has been free from fog, fog has persisted all day at Woodside Park. I am inclined to think that the prevalence of fog is mainly due to the expanse of grassland together with perhaps the valley of the Dollis Brook acting as good ground for radiation on calm, clear nights. In the more densely populated areas towards the City of London the surface of the ground is kept appreciably warmer by centrally heated buildings thus preventing to a certain extent the lowering of the temperature taking place by radiation at night and preventing the formation of fog. It would be interesting to know whether other open spots around cities have experienced similar conditions. J. MONGER

Woodside Park, N.12, March 28th, 1938.

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*We are indebted to Messrs. Rider & Co. for permission to reproduce this extract.

A Duststorm in 1836

As a result of the account of a dust devil at Haditha which appeared in the *Meteorological Magazine* for September 1937, my attention has been directed to a storm which, in the same district, wrecked the steamer " Tigris " on the river Euphrates in 1836. It may be recalled that in 1835 an expedition left England under the command of Colonel Chesney to test the navigability of the river Euphrates. The material for two iron steamers was transferred by sea to the bay of Antioch and thence across the desert to the Euphrates—a most difficult and trying undertaking.

The expedition began to move down the Euphrates in March 1836 and on May 21st had reached a point near Anah. The following account of the storm which overtook the expedition at this point is taken from Ainsworth's " Personal account of the Euphrates expedition " published in 1888.

" The wind was blowing gently from the south-east or up the river and against us but only sufficiently so as to ripple the water.

" After proceeding a short distance a dark mass of cloud was observed in the horizon to the west-south-west but as the sky had been much overcast in that direction for several days the appearance was not at first considered to be important. The cloud however continued to advance rapidly towards us, and it was seen to cling to the land or as it were to breast the surface of the desert. The awnings of both vessels were immediately furled, anchors were got in readiness, and all preparations for meeting what was evidently a portentous storm.

" As the cloud neared us, the sky assumed an appearance such as we had never before witnessed, and which was awful and terrific in the extreme. A dense black arch enveloped the whole of the horizon and the space beneath the arch was filled up with a body of dust, of a brownish orange colour, whirling round, and at the same time advancing towards us with fearful rapidity.

" At this moment the hurricane came on us—a warm dry wind, laden with the fragrance of the aromatic plants of the wilderness, with some rain in large drops. The crash broke upon us like heaven's own artillery, and the hurricane seemed as if bent upon hurling both steamers at once to the bottom of the foaming river.

" The wind in the meantime was tearing the boards from off the paddle boxes like shreds of paper and the waves rising to a height of 4 or 5 feet dashed in through the windows.

" All at once she sank casting 34 brave men upon the flood to struggle against a furious wind and a strong current with an atmosphere so charged with dust and spray that it was almost as dark as night.

" These hurricanes appear to be peculiar to great level tracts and desert spaces, from their being exposed to changes which acting upon an extensive uniform surface, unbroken by forests or mountains, accumulate with an intensity that causes them to burst over some fated spot with fearful energy and destructiveness. For the same reason, they only last a brief time, discharging almost at once their pent-up electric tension, and at the same time re-establishing an equilibrium of elasticity and pressure with the atmosphere around.

" The almost resistless impetuosity of the storms, and their whirling character, not only cause them to tear up the plants and shrubs of the wilderness, but they even carry sheep off their legs if taken unawares. These animals however, generally meet the hurricane with their legs drawn up and their noses to the ground.

" The Arabs, if on horseback, bid their steeds lie on the ground and they themselves seek shelter by the side of their bellies ; or if on foot, they lie close to the ground during the prevalence of the blast, which they call by various names, as fatulah, and samm, whence our simoon.

"Amminus relates, in his account of Julian's descent of the river in boats, that when he was at Anatho (Anah), there occurred a terrible event ; whirlwinds which blew down the houses and tents, overthrew the soldiers, and caused many boats to sink.

" Josephus writes, upon more questionable authority, that of a Sibyl, that it was by a similar phenomenon, viz. that of an impetuous wind or violent hurricane, that the tower of Babel was thrown to the ground."

Modern meteorologists will recognise in the above description many features which would now be attributed to the passage of a cold front—the sharp line of the base, the black arch of cloud enveloping the whole horizon, with the space beneath the arch filled with dust—the short duration of the storm and the sudden clearance. Such storms are common in Iraq during April and May and of course they occur frequently in the Sudan during the summer months. In Iraq the rotatory character of the storm is as a rule not marked but this feature of the Sudan haboob is always stressed.

It would of course be impossible for the average sand devil such as occurred at Haditha to cause the loss of the river steamer although no doubt many of the more restricted squalls and haboobs are sand devils on a large scale.

J. DURWARD.

Airport, Baghdad, December 15th, 1937.

Parhelion and Sun-Pillar

Last evening, April 18th, at Trefnant, Denbighshire, at 18h. 14m. a brilliantly prismatic parhelion of the halo of 22° was seen with part of the parhelic circle. After this, part of the halo itself became visible, and a faint sun-pillar ; also the upper arc of contact of 22° which slowly changed its shape as the sun's elevation diminished.

S. E. ASHMORE

Llannerch Gardens, St. Asaph, Flintshire, April 19th, 1938.

REVIEWS

Climate and Birth

A well known rhyme asks: "What is it moulds the life of man?" and answers emphatically: "The weather!". Dr. Ellsworth Huntington, in a series of important works, has traced this dominant influence from the cradle to the grave; he has now, in a book* which has attracted a great deal of attention, carried his researches back to the moment of conception and beyond, and proved that climate is of even greater importance in these early stages than later in life.

He starts by showing that in a normal temperate climate the number of births is greatest in late winter and early spring. In a savage community living in a rigorous environment the children born in spring have the greatest chance of survival, a chance which is still further increased if the parents are at their best physically at the time of conception and most active mentally when the child is new-born. Hence modern man has inherited from his savage forebears of the Ice Age two optima of temperature; his body works best at a temperature of about 63° F., characteristic of summer, and his mind at about 47° F., characteristic of spring. As a result, children tend to be conceived most readily in summer, to be born in the following spring. Social conditions, such as the periodical absence of the young men from home, may cause minor irregularities, but the underlying basic rhythm shows clearly in nearly all the curves.

As one travels from sub-arctic to sub-tropical latitudes, summer comes earlier, and so also does the maximum birth-rate, which is displaced to January in southern Spain. Within the tropics the cool season is the more favourable and conceptions are most numerous when the temperature falls to about 65° F. after the rains, when conditions are otherwise favourable.

Not only are births in temperate regions more numerous in early spring, but their quality also appears to be higher. The children born at this season tend to live longer, and to produce more eminent men and women in proportion to their numbers than those born at other seasons. Huntington has collected an immense amount of material in support of the latter conclusion, which is of considerable social importance, and some curious by-products emerge. One is that the optimum temperatures for both the conception and birth of eminent persons are appreciably lower than for the common herd. Still stranger are the curious relations between the sex ratio (i.e., the number of boys born per 100 girls) and climatic differences, both from month to month and place to place. A remarkable series of maps shows that in the U.S.A. and Europe the sex ratio is smallest in regions where the climate is most favourable for efficient work.

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* Season of birth: its relation to human abilities. New York (John Wiley & Sons, Inc., 1938, pp. VII + 473. 3.50 dollars net.)

Huntington accounts for this by an interesting physiological theory, which is directly connected with his main thesis.

All these remarkable facts give a definite clue to the climate in which modern man—*Homo sapiens*—evolved. After making allowance for the lowering of temperature during the Ice Age, our cradle is most probably located on the Iranian plateau, a finding which agrees with the results of archaeological research. They also lead to some far-reaching suggestions for the future, to give as many children as possible the advantage of being born in the right season for the climate.

C. E. P. Brooks

The Régime of the Rivers Euphrates and Tigris. By M. G. Ionides, B.A. (Oxon), Assoc.M.Inst.C.E., M.Inst.W.E. Crown quarto, 284 pp., *Illus.* E. & F. Spon, London, 1937. Price 32*s.* net.

Mr. Ionides has performed for the basin of the Twin Rivers much the same valuable service that has been done for the Nile by Col. Sir Henry Lyons[1], Sir William Willcocks[2] and Drs. H. E. Hurst and P. Phillips[3]. Would that British engineers further east might be inspired to tell us in equally lucid yet compact form something of the hydrology of such important river-basins as those of the Indus, Ganges, Brahmaputra and Murray !

The Euphrates and Tigris drain portions of four countries, Turkey, Syria, Iran (Persia) and Iraq (Mesopotamia). The lattermost, in which the author has worked, is half as large again as the British Isles together and its Administration has to deal with the problems of both excessive river-floods and shortages of irrigation-supplies.

The author first describes the methods of surface-water measurement used in Iraq and the modes in which the data thus obtained are treated statistically. He then discusses the climate of the basin, in the study of whose rainfall and other features Turks with German training and Syrians under French guidance have hitherto apparently been able to help more than the Iranians, whose deficiencies Mr. Ionides has tried to make good. By utilising a formula derived from the observations of annual rainfall and run-off in the basins of the Euphrates and of the Tigris above Mosul, he has been able to make an approximate computation of the average annual rainfall over the remaining catchment areas, and even to produce a conjectural rainfall map for the whole area.

Four chapters describe the physical features and irrigation works of the two river-systems and supply numerous statistical and graphical details of their water-levels and discharges. Three very interesting chapters discuss (i) river-bed instability, silting and scouring ; (ii) the forecasting of winter and summer discharges and levels ; and (iii) the extreme floods to be expected and their respective probabilities of occurrence.

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[1] "The Physiography of the River Nile and its Basin." Cairo, 1906.

[2] "Egyptian Irrigation," 3rd Edn. 2 vols., Spon. London, 1913.

[3] "The Nile Basin," 4 vols., Government Press. Cairo, 1931-35.

To those concerned with the study of a river-system and the interpretation of its hydrological records, in whatever country they may be, the book should form a most useful guide or example. To those in Great Britain in particular it may moreover serve in conjunction with our own observations and other cognate overseas works in our own tongue to reveal natural facts and laws of world-wide instead of merely local application.

Since Mr. Ionides is now serving in Transjordan, it is to be hoped that a further contribution to this end will eventually be received from him, surveying the last remaining of the great Biblical rivers

> " From Paneas the fount of Jordans flood
> To Bëersaba, where the Holy Land
> Borders on Aegypt and the Arabian shoare."

W. ALLARD

BOOKS RECEIVED

Onweders, optische verschijnselen, enz. in Nederland. Naar vrijwillige waarnemingen in 1934. Deel LV, Utrecht, 1936.

Cycles in tree-ring widths. By C. G. Abbot. Smithson. misc. Coll., Vol. 95, No. 19, Washington, D.C., 1936.

The Cyclone season 1933–34 at Mauritius. By N. R. McCurdy, B.Sc., Mauritius, Misc. Publ. R. Alfred Obs., No. 16, 1936.

Summary of the meteorological observations made at the meteorological stations in the Netherlands West Indies during the year 1936, compiled by the Royal Netherlands Meteorological Institute. The Hague, 1937.

Annual Report, The Climate of Palestine during the year 5696 (1935–6) and Table of Rainfall in the upper Euphrates, Syria, Lebanon, Palestine, the Sinai Peninsula and lower Egypt during the winter 5696 (1935–6). By Dr. D. Ashbel of the Hebrew University, Jerusalem, Tel-Aviv, 1937.

The Cyclone Season 1934–35 *at Mauritius.* By M. Herchenroder, B.Sc., F.R.A.S., Mauritius : Royal Alfred Observatory, Misc. Pubs. No. 17. Port Louis, 1936.

Report of the Observatory Committee to the Royal Cornwall Polytechnic Society and the Falmouth Town Council for the year 1937. Falmouth, 1938.

La distribution de la pluie des Golfes d'Egine et de Nauplie et les iles de l'Archipel du Sud. By Dr. Ath. Th. Kephalas. Athens, 1937.

A Theoretical Note on the Diurnal Variation of Wind-Vector due to the Variation of Eddy-Viscosity. By Tadao Namekawa and Tatutosi Takahasi. (Rep. Kyoto. Imp. Univ. Mem. Coll. Sc. Ser. A. Vol. XXI, No. 1, 1938.)

OBITUARY

Nicolas Sama Perez.—We have learnt with regret of the death on January 1st last of M. Sama, Director of the Spanish Meteorological Service and a member of the International Meteorological Committee. Born in 1877, M. Sama entered the service of the Central Meteorological Institute immediately after completing his education at Madrid. He became Director of the present Service, evolved by his own efforts from the nucleus of the Institute, in 1932. M. Sama was especially attracted to weather forecasting, and personally drew up the daily weather charts during a period of nearly forty years. Handicapped in recent years by ill health, he found it impossible to continue his duties under the intensive conditions of the war, and he was allowed by the Republican Government, in view of his 42 years of official service, to retire to the village of Anglesola, in the Province of Lérida, while maintaining his rank as Director of the Service. He died at Anglesola on January 1st, 1938.

Erratum.

April, 1938, p. 73, line 33, *for* " 35 m.p.h." *read* " 15 m.p.h."

The Weather of April, 1938

An intense anticyclone was centred over the British Isles, where pressure exceeded 1025 mb. in Great Britain and 1029 mb. in Ireland. Pressure decreased rapidly towards depressions over Baffin Bay in the north-west and the White Sea and Novaya Zemlya in the north-east; eastwards a ridge of high pressure (above 1015 mb.) extended across Europe to the Black Sea. Another anti-cyclone lay over Persia and the Caucasus. Pressure was also high over north-eastern Siberia. No data were received for North America. In the centre of the anticyclone over Ireland and western Britain pressure was more than 15 mb. above normal, but the Azores showed a deficit of 6 mb. and the Arctic regions were also below normal, by more than 10 mb. in northern Russia.

Temperatures differed little from normal over the British Isles, but most of Europe was abnormally cold, Switzerland and Austria having mean temperatures of only 40–45° F., more than 5° F. below normal. The Arctic regions on the other hand were generally warm, the excess being more than 5° F. from Cape Chelyuskin to north-east Greenland, and reaching 8° F. at Spitsbergen and 9° F. at Dickson. Most of Siberia was also 5 to 10° F. above normal. Rainfall was deficient over the whole of Europe and many parts, including Ireland, England and France received less than 0·5 in.

The *Weekly Weather and Crop Bulletin*, published by the U.S. Weather Bureau, shows that the beginning of the month was warm on the Atlantic coast and the Lake region but cold in the west. The second week was generally cold but the last half of the month was everywhere above normal. Rainfall did not differ greatly from the average.

No reports were received this month from Australia and New Zealand.

In the British Isles the weather of April was distinguished by an exceptional deficiency of rainfall.* Over the country generally it was by far the driest April on record. At numerous stations in Ireland and at some in south Wales and south-west England no measurable rain fell throughout the month. Sunshine was excessive on the whole except at some stations in the eastern districts of Great Britain and the extreme north of Scotland. The excess was unusual in the west; at a number of stations it was the sunniest April on record and at Valentia Observatory 262 hours is the largest total for April in a record which started in 1880. Mean temperature for the month exceeded the average in Scotland and slightly exceeded the average in Ireland and north-east England but was appreciably below the average in east and south-east England.

During the opening days a depression moved north-east from the Atlantic to the south of Iceland and then eastward to the Baltic. Gales were reported in Scotland on the 2nd and 3rd and rain occurred at times, chiefly in the northern half of the country, though rain was also experienced at most places in the south on the 2nd. The rainfall was moderately heavy locally in the north and north-west; 1·17 in. was measured at New Dungeon Ghyll and 1·28 in. at Upper Teesdale, Westmorland, on the 2nd. The 3rd was a sunny day but polar air in the rear of the depression caused a considerable fall in temperature on that day. Sleet and snow fell locally in Scotland on the 2nd and 3rd. From the 5th to 7th depressions passed east across Iceland and further local gales were reported in Scotland. Temperature rose again in the north and west on the 5th and in the south on the 6th; a maximum of 66° F. was registered at Southampton, Scarborough and Oxford on the 6th and at Cardiff and Marlborough on the 7th. On the 7th and 8th the anticyclone off west Ireland moved north and then east over the British Isles and anticyclonic conditions prevailed generally until the 15th. There was practically no rain throughout the country from the 8th to 14th. Among low minimum temperatures registered in the screen during this period were 20° F. at Dalwhinnie on the 9th, 21° F. at Eskdalemuir on the 10th and 20° F. at South Farnborough and 21° F. at Marlborough on the 11th. Subsequently the anticyclone became centred off the north-west of Ireland while pressure was low over Scandinavia and during the Easter holiday cold winds prevailed with local showers of hail, sleet and snow, though it continued dry and sunny in many parts particularly in the west. Sharp frosts occurred in some localities; a screen minimum of 20° F. was registered at Barton, Manchester, and 21° F. at Burnley and Rhayader on the 18th and 20° F. at Droitwich and Rhayader on the 19th. Thereafter the anticyclone remained over or to westward of Ireland.

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* See page 81.

There was a good deal of cloud in many parts and slight rain occurred locally at times in eastern England and Scotland, and more generally in England on the 22nd and 23rd, but the weather continued mainly dry and rather sunny over most of Ireland. A thunderstorm, accompanied by hail, occurred at Tunbridge Wells on the 25th. A trough of low pressure crossed Scotland on the 27th and caused some rain, mainly in the northern half of the country, and from the 28th to 30th the anticyclone moved north-east to the north of Scotland while a depression moved north-south-east from Jan Mayn to Germany. Local rain occurred in the eastern districts of England on the 29th and in south-east England on the 30th also. Sunshine records were good on the whole on the last three days particularly in the north and west; 14·5 hours were registered at Tiree on both the 29th and 30th and 14·4 hours at Oban on the 30th. The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ..	140	−10	Chester ..	189	+50
Aberdeen ..	121	−23	Ross-on-Wye	218	+76
Dublin	208	+49	Falmouth ..	240	+53
Birr Castle ..	229	+77	Gorleston ..	145	−19
Valentia ..	262	+101	Kew.. ..	150	+ 4

Kew, Temperature, Mean, 46·3, Diff. from average −1·4.

Miscellaneous notes on weather abroad from various sources.

After the drought which has held since the beginning of March in the Swiss canton of Ticino, many hundreds of acres of woodland were destroyed by fire in the early days of April. A hurricane off the coast of Norway caused damage to shipping, and four skiers lost their lives in a blizzard on the Norwegian mountains on the 3rd. Gales were also reported from the Riviera. A severe cold wave swept over southern Europe from the 10th until the end of the month. Snow appeared on Vesuvius on the 10th, and heavy falls occurred in Switzerland and the Italian Alps on the 19th and 21st. The sudden intense cold and frost caused widespread damage to vineyards and fruit crops in France, Switzerland and Italy, the total loss being estimated at approximately £18,000,000. (*The Times*, April 5th–26th.)

A dense sandstorm delayed all shipping in the Suez Canal on the 16th. (*The Times*, April 18th.)

Drought extended over most of Australia from the beginning of the month, but was broken by violent storms accompanied by hail in southern Australia and Victoria on the 16th–18th. Aurora was observed in Wellington, N.Z., on the 16th. Floods, reported to be the most severe in the history of the Province, occurred at Hawkes Bay, New Zealand, on the 27th. (*The Times*, April 6th–27th.)

Snow fell heavily in New York and the northern United States on the 6th. Telephone wires were broken down by blizzards in

Nebraska and Iowa, and many roads were blocked by drifts. In a tornado in Alabama, ten people were killed and 200 rendered homeless, and 12 persons were drowned in floods following a cloudburst in Georgia, Alabama and Mississippi. Central Canada experienced a severe blizzard on the 10th. Temperatures rose rapidly in New York to the 15th when 81°F. was recorded, 32°F. above normal; and on the 28th when a further record of 84°F. was attained. (*The Times,* April 7th–29th.)

Severe gales were experienced in the North Atlantic on the 9th–11th. (*The Times,* April 12th.)

Daily Readings at Kew Observatory, April, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain.	Sun.	REMARKS
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1027·6	W.3	46	63	62	—	6·8	
2	19·1	WSW.5	43	56	62	—	5·1	r_0 24h.
3	21·4	NW.5	41	52	34	0·06	10·9	r_0–r 0h.–1h. and 2h–3h.
4	30·2	WNW.2	34	52	39	—	6·3	x early.
5	23·8	SW.3	34	52	70	—	0·0	x early, ir_0 13h.–14h.
6	25·4	WNW.3	45	62	60	—	7·0	w early.
7	24·6	NW.3	41	61	50	—	8·2	
8	27·9	NNE.3	40	51	48	—	9·1	
9	32·3	NNE.4	35	47	53	—	0·6	x early.
10	40·4	ESE.3	36	51	42	—	8·4	
11	40·9	N.3	30	55	47	—	10·5	x early, m till 8h.
12	36·1	NE.4	33	60	47	—	8·7	mx till 8h.
13	28·7	NNE.3	36	59	48	—	11·0	mx till 8h.
14	25·3	NNE.4	41	55	53	—	1·8	
15	25·5	NE.4	40	54	60	—	2·1	
16	24·2	E.2	37	57	54	—	7·9	x early.
17	29·9	NNE.4	38	49	40	—	5·5	pr_0 9h.
18	31·3	N.4	33	47	50	—	6·3	pr_0 13h.
19	26·7	NNW.3	34	52	43	—	2·4	f late.
20	29·5	NNE.2	35	54	48	—	2·8	fx–m till 10h.
21	28·7	N.2	43	54	46	—	0·6	pr_0 10h.
22	20·9	NNW.4	44	54	55	—	0·7	pr_0 12h. and 14h.
23	19·9	NW.3	41	51	66	—	0·0	x early, r_0 7h.
24	23·4	N.2	42	52	72	0·02	0·5	r_0 4h–5h., r 7h.
25	21·4	NNE.3	46	54	75	—	0·8	r_0 13h. and 17h–18h.
26	21·3	ENE.3	36	53	70	—	2·0	x early, g 15h.
27	19·4	NNE.2	41	56	67	0·01	2·0	m 7h., r_0 12h–13h.
28	20·0	NE.3	38	56	48	—	5·2	r_0 13h. and 17h.
29	19·6	NNE.4	37	51	44	—	8·1	pr_0 17h.
30	1015·4	NNE.5	36	54	43	—	8·7	pr_0 18h., r_0 21h.
*	1026·0	—	39	54	53	0·09	5·0	* Means or totals.

General Rainfall for April, 1938

England and Wales	**13**	**per cent of the average 1881–1915.**
Scotland	**34**	
Ireland	**7**	
British Isles ...	**17**	

Rainfall : April, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
Lond .	Camden Square..........	·10	6	*Leics* .	Thornton Reservoir ...	·05	3
Sur .	Reigate, Wray Pk. Rd..	·11	7	,, .	Belvoir Castle...........	·03	2
Kent .	Tenterden, Ashenden...	·71	44	*Rut* .	Ridlington	·07	4
,, .	Folkestone, Boro. San.	·93	...	*Lincs* .	Boston, Skirbeck.........	·19	14
,, .	Margate, Cliftonville....	·67	50	,, .	Cranwell Aerodrome...	·16	12
,, .	Eden'bdg., Falconhurst	·36	19	,, .	Skegness, Marine Gdns.	·20	15
Sus .	Compton, Compton Ho.	·07	3	,, .	Louth, Westgate.........	·25	15
,, .	Patching Farm..........	·22	13	,, .	Brigg, Wrawby St.......	·12	...
,, .	Eastbourne, Wil. Sq....	·59	32	*Notts* .	Mansfield, Carr Bank...	·09	5
Hants.	Ventnor, Roy.Nat.Hos.	·03	2	*Derby*.	Derby, The Arboretum	·12	7
,, .	Southampton,East Park	·03	2	,, .	Buxton, Terrace Slopes	·52	18
,, .	Ovington Rectory.......	·03	2	*Ches* .	Bidston Obsy.............	·22	13
,, .	Sherborne St. John......	·07	4	*Lancs*.	Manchester, Whit. Pk.	·31	16
Herts .	Royston, Therfield Rec.	·28	18	,, .	Stonyhurst College......	1·25	46
Bucks.	Slough, Upton............	10	7	,, .	Southport, Bedford Pk.	·20	11
Oxf .	Oxford, Radcliffe.........	·10	6	,, .	Ulverston, Poaka Beck	·52	17
N'hant	Wellingboro, Swanspool	·07	5	,, .	Lancaster, Greg Obsy.	·47	21
,, .	Oundle	·07	...	,, .	Blackpool	·24	13
Beds .	Woburn, Exptl. Farm...	·12	8	*Yorks*.	Wath-upon-Dearne......	·14	9
Cam .	Cambridge, Bot. Gdns.	·17	13	,, .	Wakefield,Clarence Pk.	·08	5
,, .	March......................	·50	38	,, .	Oughtershaw Hall.......	1·14	...
Essex.	Chelmsford,County Gdns	·28	22	,, .	Wetherby, Ribston H..	·05	3
,, .	Lexden Hill House......	·34	...	,, .	Hull, Pearson Park......	·31	20
Suff .	Haughley House.........	·36	...	,, .	Holme-on-Spalding......	·14	8
,, .	Rendlesham Hall........	·47	33	,, .	Felixkirk, Mt. St. John.	·28	17
,, .	Lowestoft Sec. School...	·82	55	,, .	York, Museum Gdns....	·10	6
,, .	Bury St. Ed., WestleyH.	·54	35	,, .	Pickering, Houndgate...	·21	13
Norf. .	Wells, Holkham Hall...	·26	20	,, .	Scarborough...............	·26	17
Wilts .	Porton, W.D. Exp'l. Stn	·03	2	,, .	Middlesbrough............	·11	8
,, .	Bishops Cannings........	·22	11	,, .	Baldersdale, Hury Res.	·60	25
Dor .	Weymouth, Westham.	·11	7	*Durh* .	Ushaw College............	·09	5
,, .	Beaminster, East St....	·19	8	*Nor* .	Newcastle, Leazes Pk...	·13	8
,, .	Shaftesbury,Abbey Ho.	·03	1	,, .	Bellingham, Highgreen	·31	14
Devon.	Plymouth, The Hoe....	·19	8	,, .	Lilburn Tower Gdns....	·41	21
,, .	Holne, Church Pk. Cott.	·22	6	*Cumb*.	Carlisle, Scaleby Hall...	·56	29
,, .	Teignmouth, Den Gdns.	·09	4	,, .	Borrowdale, Seathwaite	2·00	29
,, .	Cullompton	·22	10	,, .	Thirlmere, Dale Head H.	1·14	24
,, .	Sidmouth, U.D.C........	·04	...	,, .	Keswick, High Hill......	·53	17
,, .	Barnstaple, N. Dev.Ath	·13	6	,, .	Ravenglass, The Grove	·25	10
,, .	Dartm'r,Cranmere Pool	·80	...	*West* .	Appleby, Castle Bank...	·24	12
,, .	Okehampton, Uplands.	...	...	*Mon* .	Abergavenny, Larchf'd	·04	2
Corn .	Redruth, Trewirgie......	·02	1	*Glam* .	Ystalyfera, Wern Ho....	·41	11
,, .	Penzance, Morrab Gdns.	·03	1	,, .	Treherbert, Tynywaun.	·53	...
,, .	St. Austell, Trevarna...	·10	4	,, .	Cardiff, Penylan..........	·17	7
Soms .	Chewton Mendip.........	·26	9	*Carm* .	Carmarthen,M. & P. Sch.	·05	2
,, .	Long Ashton............	·25	11	*Pemb* .	Pembroke,Stackpole Ct.	·00	0
,, .	Street, Millfield..........	·05	3	*Card* .	Aberystwyth	·32	...
Glos .	Blockley	·11	...	*Rad* .	BirmW.W.Tyrmynydd	·57	15
,, .	Cirencester, Gwynfa....	·11	6	*Mont* .	Newtown, Penarth Weir	...	...
Here .	Ross-on-Wye.............	·06	3	,,	Lake Vyrnwy	·30	10
Salop .	Church Stretton.........	·21	10	*Flint* .	Sealand Aerodrome......	·20	14
,, .	Shifnal, Hatton Grange	·13	8	*Mer* .	Blaenau Festiniog	1·03	18
,, .	Cheswardine Hall........	·09	5	,, .	Dolgelley, Bontddu......	1·10	30
Worc .	Malvern, Free Library...	·06	3	*Carn* .	Llandudno	·28	17
,, .	Ombersley, Holt Lock.	·04	3	,, .	Snowdon, L. Llydaw 9..	2·20	...
War .	Alcester, Ragley Hall...	·13	8	*Ang* .	Holyhead, Salt Island...	·21	10
,, .	Birminghm, Edgbaston	·10	6	,, .	Lligwy	·37	...

Rainfall: April, 1938: Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cen of Av.
I. Man	Douglas, Boro' Cem.	·41	17	*R&C*	Achnashellach	3·23	57
Guern.	St.Peter P't.Grange Rd.	·04	2	,,	Stornoway,C.GuardStn.	·85	30
Wig	Pt. William, Monreith.	·26	12	*Suth*	Lairg	1·69	73
,,	New Luce School	·69	26	,,	Skerray Borgie	2·20	...
Kirk	Dalry, Glendarroch	·62	20	,,	Melvich	1·33	57
Dumf.	Dumfries, Crichton R.I.	·29	13	,,	Loch More, Achfary	3·87	80
,,	Eskdalemuir Obs	·92	27	*Caith*	Wick	1·56	78
Roxb	Hawick, Wolfelee	·17	8	*Ork*	Deerness	1·44	70
Peeb	Stobo Castle	·36	17	*Shet*	Lerwick Observatory	1·56	68
Berw	Marchmont House	·38	19	*Cork*	Cork, University Coll.	·10	4
E.Lot	North Berwick Res	·05	4	,,	Roches Point, C.G. Stn.	·02	1
Midl	Edinburgh, Blackfd. H.	·15	10	,,	Mallow, Longueville	·06	2
Lan	Auchtyfardle	·53	...	*Kerry*	Valentia Observatory	·09	2
Ayr	Kilmarnock, Kay Park	·66	...	,,	Gearhameen	·30	5
,,	Girvan, Pinmore	·55	19	,,	Bally McElligott Rec.	·13	...
,,	Glen Afton, Ayr San.	·83	27	,,	Darrynane Abbey	·05	1
Renf	Glasgow, Queen's Park	·57	29	*Wat*	Waterford, Gortmore	·00	0
,,	Greenock, Prospect H.	·85	25	*Tip*	Nenagh, Castle Lough.	·40	16
Bute	Rothesay, Ardencraig	·37	12	,,	Cashel, Ballinamona	·10	4
,,	Dougarie Lodge	·53	19	*Lim*	Foynes, Coolnanes	·22	9
Arg	Loch Sunart, G'dale	1·22	29	*Clare*	Inagh, Mount Callan	·55	...
,,	Ardgour House	2·45	...	*Wexf*	Gorey, Courtown Ho.	·03	1
,,	Glen Etive	...	...	*Wick*	Rathnew, Clonmannon.	·00	...
,,	Oban	1·02	...	*Carl*	Bagnalstown,Fenagh H.	·06	3
,,	Poltalloch	·72	24	,,	Hacketstown Rectory	·09	3
,,	Inveraray Castle	1·98	43	*Leix*	Blandsfort House	·05	2
,,	Islay, Eallabus	·49	17	*Offaly*	Birr Castle	·15	7
,,	Mull, Benmore	2·40	31	*Kild*	Straffan House	·11	6
,,	Tiree	·35	14	*Dublin*	Dublin, Phoenix Park.	·06	3
Kinr	Loch Leven Sluice	·24	13	,,	Balbriggan, Ardgillan	...	...
Fife	Leuchars Aerodrome	·08	5	*Meath*	Kells, Headfort	·01	0
Perth	Loch Dhu	1·50	32	*W.M*	Moate, Coolatore	·11	...
,,	Crieff, Strathearn Hyd.	·29	13	,,	Mullingar, Belvedere	·21	9
,,	Blair Castle Gardens	·46	22	*Long*	Castle Forbes Gdns	·12	5
Angus.	Kettins School	·09	5	*Gal*	Galway, Grammar Sch.	·21	9
,,	Pearsie House	·45	...	,,	Ballynahinch Castle	·50	14
,,	Montrose, Sunnyside	·34	19	,,	Ahascragh, Clonbrock.	·10	4
Aber	Balmoral Castle Gdns.	·40	19	*Rosc*	Strokestown, C'node	·19	9
,,	Logie Coldstone Sch.	·53	26	*Mayo.*	Blacksod Point	·37	13
,,	Aberdeen Observatory.	·78	42	,,	Mallaranny	·65	...
,,	New Deer School House	·69	35	,,	Westport House	·24	9
Moray	Gordon Castle	·47	27	,,	Delphi Lodge	1·07	19
,,	Grantown-on-Spey	·75	38	*Sligo*	Markree Castle	·39	15
Nairn.	Nairn	·48	32	*Cavan.*	Crossdoney, Kevit Cas.	·17	...
Inv's	Ben Alder Lodge	1·87	...	*Ferm*	Crom Castle	·15	6
,,	Kingussie, The Birches.	·59	...	*Arm*	Armagh Obsy	·08	4
,,	Loch Ness, Foyers	·83	38	*Down.*	Fofanny Reservoir	·33	...
,,	Inverness, Culduthel R.	·47	28	,,	Seaforde	·13	5
,,	Loch Quoich, Loan	7·23	...	,,	Donaghadee, C. G. Stn.	·20	10
,,	Glenquoich	5·52	85	*Antr*	Belfast,Queen's Univ.	·30	13
,,	Arisaig House	1·31	37	,,	Aldergrove Aerodrome.	·24	11
,,	Glenleven, Corrour	2·15	53	,,	Ballymena, Harryville.	·51	19
,,	Fort William, Glasdrum	1·77	...	*Lon*	Garvagh, Moneydig	·25	...
,,	Skye, Dunvegan	1·27	...	,,	Londonderry, Creggan.	·69	27
,,	Barra, Skallary	·91	...	*Tyr*	Omagh, Edenfel	·38	14
R&C.	Tain, Ardlarach	·80	41	*Don*	Malin Head	·52	21
,,	Ullapool	1·57	51	,,	Dunkineely	·98	...

Climatological Table for the British Empire, November, 1937

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean.							
	Mean of Day M.S.L. mb.	Diff. from Normal. mb.	Max. °F.	Min. °F.	Max. °F.	Min. °F.	½ Max. and Min. °F.	Diff. from Normal. °F.	Wet Bulb. °F.	%	0–10	Am'nt. in.	Diff. from Normal. in.	Days.	Hours per day.	Per-centage of possible.
London, Kew Obsy....	1017·2	+ 2·6	55	25	46·9	37·2	42·1	− 1·4	39·2	94	8·0	1·38	− 0·84	10	1·5	17
Gibraltar	1017·0	− 1·0	72	53	65·8	57·9	61·9	+ 1·9	57·9	88	6·5	1·82	...	11	...	...
Malta........	1015·3	− 0·6	76	53	69·3	60·7	65·0	+ 1·1	63·1	75	5·1	1·78	− 1·79	10	6·8	67
St. Helena	1013·4	− 0·5	68	54	63·0	56·1	59·5	+ 1·0	57·0	95	9·9	0·76	− 0·42	12	...	...
Freetown, Sierra Leone	1011·4	+ 2·2	89	70	86·4	73·4	79·9	...	75·8	80	5·6	2·95	− 2·17	12	...	...
Lagos, Nigeria	1011·1	+ 1·0	92	71	88·6	74·7	81·7	0·0	76·8	87	5·7	0·38	− 2·29	4	8·6	73
Kaduna, Nigeria	1012·8	...	94	53	91·0	58·2	74·6	− 1·6	61·4	64	5·2	0·00	− 0·21	0	9·7	84
Zomba, Nyasaland	1009·4	+ 0·5	95	58	86·2	66·0	76·1	+ 0·5	73·3	83	4·4	4·68	− 0·40	6	...	...
Salisbury, Rhodesia...	1009·6	− 0·6	95	56	85·3	60·5	72·9	+ 2·2	60·9	47	3·2	2·83	...	13	9·1	71
Cape Town	1015·8	0·0	92	47	75·9	56·7	66·3	+ 1·9	59·5	72	5·7	1·03	− 0·06	11	...	...
Johannesburg	1010·2	+ 0·4	90	47	81·0	55·6	68·3	+ 4·6	56·2	46	2·5	2·41	− 2·55	9	9·8	73
Mauritius	1015·2	− 0·9	88	64	83·1	68·9	76·0	+ 0·5	71·6	67	5·1	3·59	+ 1·83	17	9·8	75
Calcutta, Alipore Obsy.	1012·7	− 0·6	89	57	84·0	65·1	74·5	+ 1·0	67·1	85	2·0	0·15	− 0·50	1*	...	...
Bombay	1010·4	− 1·6	94	70	91·0	74·0	82·5	+ 1·9	71·5	70	3·0	0·00	− 0·45	0*	...	...
Madras	1010·2	− 1·1	87	69	82·6	72·8	77·7	− 1·2	74·0	87	8·4	24·61	+ 11·00	13*	...	...
Colombo, Ceylon	1009·3	− 0·7	88	73	84·7	74·1	79·4	− 0·6	76·6	81	7·3	18·00	+ 6·24	24	4·7	40
Singapore........	1009·1	− 0·3	89	72	85·8	74·9	80·3	− 0·3	77·3	79	7·1	9·00	− 0·91	17	5·3	44
Hongkong........	1016·3	− 1·3	84	53	76·5	66·7	71·6	+ 2·0	65·2	71	6·5	1·03	− 0·71	1	6·1	55
Sandakan	1008·4	...	90	73	87·2	75·3	81·3	+ 0·4	77·9	84	7·7	16·23	+ 1·51	19	...	...
Sydney, N.S.W........	1017·3	+ 3·5	93	53	73·4	61·6	67·5	+ 0·5	62·1	65	7·6	3·66	+ 0·81	15	7·1	51
Melbourne	1017·2	+ 2·8	99	44	74·0	54·7	64·3	+ 3·0	57·0	57	7·1	0·40	− 1·83	5	6·6	47
Adelaide........	1016·9	+ 1·6	106	45	81·5	58·1	69·8	+ 2·8	59·2	40	4·8	1·39	+ 0·25	9	8·7	63
Perth, W. Australia ...	1015·1	− 0·3	95	49	77·4	59·0	68·2	+ 2·1	59·6	53	4·7	0·67	− 0·13	7	9·8	71
Coolgardie	1013·7	+ 0·3	97	41	82·0	54·1	68·1	− 2·6	60·3	58	5·0	1·59	+ 1·00	6	...	...
Brisbane........	1015·6	+ 1·0	101	58	78·9	64·4	71·7	− 1·8	66·1	69	7·5	7·94	+ 4·21	17	6·1	45
Hobart, Tasmania........	1015·1	+ 5·5	98	40	68·3	51·0	59·7	+ 2·5	53·9	56	5·7	0·75	− 1·72	10	7·9	55
Wellington, N.Z.	1014·8	+ 2·7	75	41	64·4	50·0	57·2	+ 0·4	54·8	74	6·1	2·90	− 0·62	9	7·9	55
Suva, Fiji	1012·0	+ 0·9	88	69	83·6	73·3	78·5	+ 1·4	73·3	78	7·6	5·87	− 3·92	19	5·8	45
Apia, Samoa	1009·1	− 0·4	89	70	85·6	74·4	80·0	+ 1·3	75·7	74	4·6	4·56	− 5·27	11	7·5	59
Kingston, Jamaica	1010·4	− 2·0	89	68	85·6	72·2	78·9	− 0·4	71·7	91	7·3	5·39	+ 2·36	15	5·7	50
Grenada, W.I.	1011·0	+ 0·4	89	70	86	73	79·5	0·0	73	74	4	6·89	− 1·57	19	...	...
Toronto........	1016·3	− 1·0	59	20	43·9	33·2	38·5	+ 1·5	...	...	6·8	1·80	− 0·83	13	3·0	31
Winnipeg	1017·2	− 0·2	53	−11	29·8	16·4	23·1	+ 1·8	...	...	5·1	0·46	− 0·61	3	2·4	26
St. John, N.B.	1015·3	+ 0·7	53	19	43·6	30·1	36·9	+ 0·2	33·6	82	6·7	3·90	− 0·51	15	3·0	31
Victoria, B.C........	1013·0	− 2·9	59	29	50·0	42·2	46·1	+ 1·6	45·8	93	9·1	4·56	− 0·85	21	1·9	20
Addendum:																
Brisbane—July	1023·8	+ 5·4	77	42	68·2	49·9	59·1	+ 0·6	52·6	70	4·1	1·15	− 1·05	13	6·8	64
October	1015·3	− 0·9	[illegible]	58	81·5	62·5	72·0	+ 2·2	63·9	57	4·3	3·59	+ 1·06	8	8·7	68

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Climatological Table for the British Empire, November, 1937

STATIONS.	PRESSURE.		TEMPERATURE.							Rela-tive Hum-idity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean.							
	Mean of Day M.S.L.	Diff. from Normal.	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.			Am'nt.	Diff. from Normal.	Days.	Hours per day.	Per-cent-age of possi-ble.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1017·2	+ 2·6	55	25	46·9	37·2	42·1	− 1·4	39·2	94	8·0	1·38	− 0·84	10	1·5	17
Gibraltar	1017·0	− 1·0	72	53	65·8	57·9	61·9	+ 1·9	57·9	88	6·5	1·82	...	11	...	...
Malta	1015·3	− 0·6	76	53	69·3	60·7	65·0	+ 1·1	63·1	75	5·1	1·78	− 1·79	10	6·8	67
St. Helena	1013·4	− 0·5	68	54	63·0	56·1	59·5	+ 1·0	57·0	95	9·9	0·76	− 0·42	12	...	...
Freetown, Sierra Leone	1011·4	+ 2·2	89	70	86·4	73·4	79·9	...	75·8	80	5·6	2·95	− 2·17	12	...	...
Lagos, Nigeria	1011·1	+ 1·0	92	71	88·6	74·7	81·7	0·0	76·8	87	5·7	0·38	− 2·29	4	8·6	73
Kaduna, Nigeria	1012·8	...	94	53	91·0	58·2	74·6	− 1·6	61·4	64	5·2	0·00	− 0·21	0	9·7	84
Zomba, Nyasaland	1009·4	+ 0·5	95	58	86·2	66·0	76·1	+ 0·5	73·3	83	4·4	4·68	− 0·40	6	...	...
Salisbury, Rhodesia	1009·6	− 0·6	95	56	85·3	60·5	72·9	+ 2·2	60·9	47	3·2	2·83	...	13	9·1	71
Cape Town	1015·8	0·0	92	47	75·9	56·7	66·3	+ 1·9	59·5	72	5·7	1·03	− 0·06	11	...	...
Johannesburg	1010·2	+ 0·4	90	47	81·0	55·6	68·3	+ 4·6	56·2	46	2·5	2·41	− 2·55	9	9·8	73
Mauritius	1015·2	− 0·9	88	64	83·1	68·9	76·0	+ 0·5	71·6	67	5·1	3·59	+ 1·83	17	9·8	75
Calcutta, Alipore Obsy.	1012·7	− 0·6	89	57	84·0	65·1	74·5	+ 1·0	67·1	85	2·0	0·15	− 0·50	1*	...	...
Bombay	1010·4	− 1·6	94	70	91·0	74·0	82·5	+ 1·9	71·5	70	3·0	0·00	− 0·45	0*	...	...
Madras	1010·2	− 1·1	87	69	82·6	72·8	77·7	− 1·2	74·0	87	8·4	24·61	+ 11·00	13*	...	...
Colombo, Ceylon	1009·3	− 0·7	88	73	84·7	74·1	79·4	− 0·6	76·6	81	7·3	18·00	+ 6·24	24	4·7	40
Singapore	1009·1	− 0·3	89	72	85·8	74·9	80·3	− 0·3	77·3	79	7·1	9·00	− 0·91	17	5·3	44
Hongkong	1016·3	− 1·3	84	53	76·5	66·7	71·6	+ 2·0	65·2	71	6·5	1·03	− 0·71	1	6·1	55
Sandakan	1008·4	...	90	73	87·2	75·3	81·3	+ 0·4	77·9	84	7·7	16·23	+ 1·51	19	...	...
Sydney, N.S.W.	1017·3	+ 3·5	93	53	73·4	61·6	67·5	+ 0·5	62·1	65	7·6	3·66	+ 0·81	15	7·1	51
Melbourne	1017·2	+ 2·8	99	44	74·0	54·7	64·3	+ 3·0	57·0	57	7·1	0·40	− 1·83	5	6·6	47
Adelaide	1016·9	+ 1·6	106	45	81·5	58·1	69·8	+ 2·8	59·2	40	4·8	1·39	+ 0·25	9	8·7	63
Perth, W. Australia	1015·1	− 0·3	95	49	77·4	59·0	68·2	+ 2·1	59·6	53	4·7	0·67	− 0·13	7	9·8	71
Coolgardie	1013·7	+ 0·3	97	41	82·0	54·1	68·1	− 2·6	60·3	58	5·0	1·59	+ 1·00	6	...	...
Brisbane	1015·6	+ 1·0	101	58	78·9	64·4	71·7	− 1·8	66·1	69	7·5	7·94	+ 4·21	17	6·1	45
Hobart, Tasmania	1015·1	+ 5·5	98	40	68·3	51·0	59·7	+ 2·5	53·9	56	5·7	0·75	− 1·72	10	7·9	55
Wellington, N.Z.	1014·8	+ 2·7	75	41	64·4	50·0	57·2	+ 0·4	54·8	74	6·1	2·90	− 0·62	9	7·9	55
Suva, Fiji	1012·0	+ 0·9	88	69	83·6	73·3	78·5	+ 1·4	73·3	78	7·6	5·87	− 3·92	19	5·8	45
Apia, Samoa	1009·1	− 0·4	89	70	85·6	74·4	80·0	+ 1·3	75·7	74	4·6	4·56	− 5·27	11	7·5	59
Kingston, Jamaica	1010·4	− 2·0	89	68	85·6	72·2	78·9	− 0·4	71·7	91	7·3	5·39	+ 2·36	15	5·7	50
Grenada, W.I.	1011·0	+ 0·4	89	70	86	73	79·5	0·0	73	74	4	6·89	− 1·57	19	...	...
Toronto	1016·3	− 1·0	59	20	43·9	33·2	38·5	+ 1·5	...	...	6·8	1·80	− 0·83	13	3·0	31
Winnipeg	1017·2	− 0·2	53	−11	29·8	16·4	23·1	+ 1·8	...	...	5·1	0·46	− 0·61	3	2·4	26
St. John, N.B.	1015·3	+ 0·7	53	19	43·6	30·1	36·9	+ 0·2	33·6	82	6·7	3·90	− 0·51	15	3·0	31
Victoria, B.C.	1013·0	− 2·9	59	29	50·0	42·2	46·1	+ 1·6	45·8	93	9·1	4·56	− 0·85	21	1·9	20
Addendum:																
Brisbane—July	1023·8	+ 5·4	77	42	68·2	49·9	59·1	+ 0·6	52·6	70	4·1	1·15	− 1·05	13	6·8	64
October	1015·3	− 0·9	99	58	81·5	62·5	72·0	+ 2·2	63·9	57	4·3	3·59	+ 1·06	8	8·7	68

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

(41920) Wt. 21/31 1125 5/38 Hw. G.377/6

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The Practice of Meteorological Observation 80 years ago.

By H. E. Carter

Early climatological records of the Scottish Meteorological Society show interesting differences from present day methods of observation. This note is devoted chiefly to these differences, but the relative continuity, in essentials, with present day practice, shows that the earliest nationally organized observations were made on carefully considered lines. The fact that an Edinburgh publication of 1796 contains a specimen monthly register strongly reminiscent of M.O. Form 3203 confirms that a much earlier experience was available.*

Observations for a large number of stations commenced in 1856 but the earliest regular records on printed schedules preserved in the Meteorological Office, Edinburgh, are those for the year 1857. They are written—mostly in handwriting which excites admiration—on large forms, about 23 in. by 18 in. One side contains a month's observations and spaces are provided at the bottom of the sheet for the preparation of summaries in a form not very different from that adopted at official climatological stations to-day. On the reverse side are entered phenological observations such as dates of flowering of trees and shrubs and the appearance of migratory birds; and also details of crops under the headings "Dates of sowing," "Appearing above ground," "In ear or flower," and "First cut."

From instructions printed on the forms, it seems that the observer was allowed considerable latitude in regard to the time of observation: "The Society recommends a quarter before nine o'clock, morning and evening, as the most convenient hour; but should this be inconvenient for the observer, another hour may be chosen, attending however, to the rule that morning and evening readings be taken at the same hour." As to the barometer, we are told that "it ought always to be gently tapped before taking the reading." For methods of reduction etc. reference is made to the " Report of the Committee of the Royal Society on Physics and Meteorology," 1840. In regard to thermometers, it is stated that " the maximum registering thermometer, for taking the extreme heat of the sun's rays, should have its bulb blackened and the surface rendered dull " and the grass minimum thermometer " should have its bulb similarly blackened and rendered dull." " Different contrivances " are mentioned for housing the thermometers. The well known Stevenson Screen was not introduced until some years later, 1864, but its forerunner seems to have been " a double meat-safe ventilated box with louvre-boarded sides." Again—" As Fleming's* Rain Gauges seem to possess several advantages over others, the Society gives the preference to them ; but whatever form be employed, in order that all the stations may give comparable results, it is recommended that the gauge be sunk in the ground so that the top of the receiver is nearly on a level with the top blades of close cut grass." (In 1859 Glaisher set up the gauge of his own design at Hartwell, Bucks, with the rim 6 inches above ground.†) There is evidence of some concern on the question of dating ; one observer mentions that his observations are for the " 24 hours previous to 9.30 a.m." while another tells us that he reads his raingauge at midnight, a striking example of devotion to the science.

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* F. E. Dixon, *Met. Mag.* Nov. 1937, p. 239.

The Beaufort Scale of wind force does not seem to have come into general use at Scottish land stations until 1905 though a modified Beaufort Scale was used at Ben Nevis in 1883. At lighthouses the Beaufort Scale was in use in 1868 and probably much earlier. In 1796 a scale of 0 to 4 had been recommended. In the monthly forms for 1857 it was " generally agreed to reckon the force of the wind from 0 to 6, the latter being the severest hurricane in this island." Decimals were used in the lower ranges of this scale. By 1859 the use of Lind's Anemometer was recommended for obtaining the greatest force of the wind during the period of observation, the estimation by scale being " to say the least, unsatisfactory." After another two years the Council of the Society strongly recommended " that every observer be furnished with a Hemispherical Cup Anemometer, a self-registering instrument which shows the amount of wind that passes it per day ; from which also the velocity of the wind at the time of observation may be ascertained." The observer was left to fill in the unit used for force or speed and several observers give values in pounds per square foot.

Cloud amounts are given according to the present day scale, 0 — 10. There is an interesting reference to the possible effect of the full moon on clouds : " As the full moon, so long as it is above the horizon, is thought by some eminent astronomers to have a powerful effect in dispelling clouds, it would be well to note in the general observations any facts bearing on this point for a few days (or nights, as the case may be) before and after every full moon ; and the same observation ought to be made at the periods of new moon." The amount of sunshine was represented in 1857 in fractional form, the denominator indicating the possible duration and the numerator the number of hours the sun shone. This form of expression did not last long and in 1859 a single number represented " the number of hours the sun shines." Two years later (1861) the observer was instructed to enter " the number of hours objects in the sun's rays cast shadows." This latter change suggests that even in those days a tendency to over-estimation was in existence and this is confirmed by the frequency of entries of 16, 17 and even 18 hours sunshine a day, in the summer months at Northern stations.

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* A 3 inch float gauge. See *British Rainfall*, 1868, p. 22.

† *Speculum Hartwellianum*, 1860.

The observer of 1857 was encouraged to make observations of ground temperature at depths of 3 and 12 inches " to ascertain the temperature of what may be termed the agricultural soil." In 1859 a third ground temperature, at 22 inches, was added. Provision was made for entering the temperatures of springs or deep wells, and, at coastal stations, of sea temperature and density. Some stations gave observations of ozone and also of electricity. The electrometer used for the latter observation is thus described : " pith balls suspended by a silk thread, in connection with a metallic conductor, and under cover, the degrees of a circle being used to express the degree of repulsion." The effects of weather on the life of the people, the harvest, the health of cattle, shipping, etc. come in for more frequent comment than is nowadays the case. Judging by a remark of the minister at Bressay (Shetland) the weather of January 1859 was at least as severe as in some recent winters. He describes it as " the most changeable and violent of any corresponding month ever remembered in this district ; constant gales of wind and violent rain almost continually." Local pride is evident in a note by a minister in the far north, who, in referring to one of the Society's reports, says : " I am gratified to find that the climate of Orkney has attracted the notice it deserves." There is a preponderance of " twopenny blues " among the postage stamps on these forms, that representing the charge for postage in those days. The observer was warned in a footnote that no wax or wafers were to be employed in closing the schedule for posting.

A footnote to the schedules in 1861 reads " Returns from the ' Principal Towns ' should be in Edinburgh not later than the 2nd." —a reference to the towns whose records were utilized then, as now, in the monthly tables prepared for the reports of the Registrar General for Scotland.

One wonders whether these early co-operators in an organized system of recording meteorological data ever visualized that more than 80 years later officials would be consulting their original records in connection with questions of public importance.

Duststorms in India

By R. G. VERYARD.

The prediction of duststorms is an important and by no means easy part of the routine work of an aviation forecaster in India. It is not sufficient to warn aircraft that conditions will be favourable for duststorms ; a pilot wishes to know the time and duration of the duststorm, the strength of the winds associated therewith, and, if possible, the width, depth and vertical extent of the dust curtain. With a limited amount of data at his disposal, the forecaster cannot hope to give all this information accurately, particularly as the formation of duststorms is still imperfectly understood ; important questions have still to be answered. With increased research, however, a more detailed knowledge about these phenomena is being obtained. In the article under review Sreenivasaiah and Sur of the India Meteorological Department describe their investigation into the thermodynamics of duststorms*.

The authors commence with the statement that a duststorm is not essentially different from a thunderstorm except that the former is associated with less precipitation. A distinction is made, quite rightly, between a duststorm and a mere dust-raising wind ; at a place like Peshawar the latter is often a föhn wind. The writer's own experience is that duststorms may have the character of thunderstorms due, perhaps, to local instability in which case the width of the dust curtain is limited to about 20 miles or less ; or that the storms may be associated with fronts, in which case the dust curtain may extend in a line for 100 or even 200 miles. Some duststorms are accompanied, preceded or followed by thunder, rain or even hail ; some occur with an almost cloudless sky ; and by no means are all the thunderstorms of the Indian hot weather accompanied by duststorms. It is interesting to note that Farquharson (1) considers that haboobs, the duststorms of the Sudan, are associated with thunder-squalls. On the other hand, Sutton (2) suggested that they might be frontal phenomena although in a later paper (3) his views are more in keeping with those of Farquharson. Many years ago, Hankin (4) classified the storms into (a) *primary*, in which the dust is raised locally, and (b) *derived*, in which the dust has been brought from a distance. In the case of some of the duststorms in America and Australia it has also been shown that the dust has been carried along for hundreds of miles. It is certain, therefore, that all duststorms are not simply " local " phenomena. This means that one cannot rely entirely upon local upper air soundings for the prediction of duststorms but must consider the possibility of a change of air mass. Actually in the paper by Sur and Sreenivasaiah instances are referred to when duststorms were associated with the passage of a front. (Even local thunderstorms, of course, are often accompanied by a local or minor front.)

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* Sreenivasaiah, B. N. and Sur, N.K. The thermodynamics of duststorms. *Curr. Sci., Bangalore,* 6, 1937, pp. 209–212.

Regarding the meteorological conditions associated with a duststorm, the authors state that a marked sudden drop in temperature is one of the usual features. The writer would like to mention here that it is by no means rare for a duststorm at Peshawar to be accompanied at first by a slight rise of temperature and a marked drop in humidity, the fall in temperature occurring subsequently. These conditions are attributable presumably to the descent of air—accentuated perhaps by the travel of air over the hills—occurring at the first front of a " double " cold front. European meteorologists are familiar with this type of cold front, the explanation of which has been given by J. Bjerknes (5).

The diurnal and monthly frequencies of duststorms which the authors have computed for Agra resemble closely the frequencies which the writer worked out for Peshawar, although the total number is actually greater at the latter station. At both places—in fact over north-west India generally—the monthly frequency curves show two maxima. The first occurs in the hot dry transition season preceding the onset of the south-west monsoon, when the track of the western disturbances has receded northwards beyond the plains of northern India ; the supply of moisture is then limited and, except with the passage of feeble occlusions or an early incursion of monsoon air, there is little cloud. The secondary maximum, which is much smaller than the first, occurs in the transition season following the retreat of the south-west monsoon ; the western disturbances do not normally re-appear, even in Kashmir, until mid-November or later and there is rather less cloud than in the first transition period. Yet, during the monsoon period when there is plenty of moisture available and when conditions might be expected to be more unstable, duststorms are comparatively rare. Also, although duststorms are more frequent in the afternoons, they may occur at any time of the day and are by no means uncommon at night. In fact, as the authors point out, although insolation plays an important part in the production of duststorms, there is no doubt that these phenomena are often attributable to the passage of a front. It is hoped that in the fuller account of their investigations into the causes of and conditions associated with duststorms the authors will produce some examples of frontal analysis.

It is readily understood that these storms are associated with the existence of a state of latent instability in the atmosphere and that some sort of trigger action may be required to start them off. When, however, the authors go so far as to select an isolated occasion which they call a " typical instance of the analysis " and proceed to state that a particle having been forced to rise from the ground into the environment of latent instability would, at a specified height, acquire a speed of 35–40 m.p.h. one looks for the proof. Evidently the authors have made their calculations in accordance with the method given by Normand (6). Dr. Normand, however, makes it clear that his computations are based on certain assumptions—he ignores, for example, the effect of friction—and states that the method simply gives the order of magnitude of the velocity developed.

In view of the great heights to which the dust is lifted in a duststorm it would be interesting to evaluate the coefficient of eddy diffusion. Whilst stationed in India, the writer made an attempt to determine experimentally the degree of turbulence and the amount of dust in the atmosphere during duststorms at Peshawar but only a few rather unsatisfactory observations could be made before returning to England. In his paper on dust-raising winds Normand (7) derives the following equation relating the density of the dust to the degree of turbulence in the air :—

$$\frac{dm}{dt} = k\frac{d^2m}{dz^2} + v\frac{dm}{dz}$$

where m = the number of dust particles in a unit volume at height z above the surface

k = coefficient of eddy diffusion.

v = limiting velocity of fall of the dust particles.

Treating, as a first approximation, k and v as constants independent of z one obtains for a " steady " state, i.e. $dm/dt = 0$,

$$k \log m + vz = \text{constant} = k \log m_0$$

where m_0 is the value of m at $z = 0$

$$\text{Hence } \log \frac{m_0}{m} = \frac{vz}{k} \text{ or } m = m_0 e^{-vz/k}$$

Since particles of different sizes have different rates of fall it is necessary to apply the above equation separately for given sizes. Hence, if the steady state is reached approximately, and if the concentration at ground-level of particles of sizes 1, 2, 3, are $m_0{}^1$, $m_0{}^2$, $m_0{}^3$......respectively, then one would expect the concentrations of the different sizes at height z to be $m_0{}^1 e^{-v_1 z/k}$, $m_0{}^2 e^{-v_2 z/k}$,......etc.

It occurred to the writer that it would be most interesting to obtain values of $m_0{}^1$, $m_0{}^2$, $m_0{}^3$......etc., at ground level and of $m^1{}_z$, $m^2{}_z$, $m^3{}_z$ etc. for various values of z. One could then theorize legitimately because observations of the distribution of dust would be available to check one's theories.

It was intended therefore to get a good set of observations, for various heights, of (*a*) the total weight of dust per unit volume of air and (*b*) fractional weights or numbers of different sizes of particles. It was expected that the assortment of particles at each height would be according to the normal frequency curve. The abscissae could be chosen to represent concentrations (or weights per unit volume) of each range of size of particle so that the area of the whole curve would represent total weight of dust per unit volume. It was hoped to pass from a frequency curve of weights to a frequency curve of numbers of particles or from a curve of numbers to a curve of weights, by calculation, after checking by sample experiments the assumption made in making the calculation.

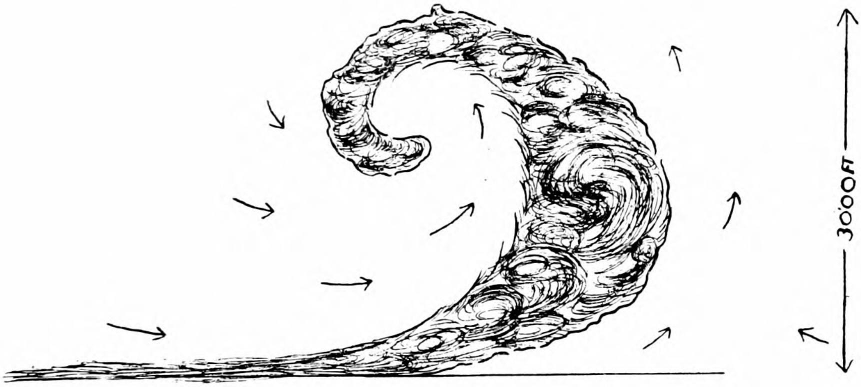

FIG. 1.—SIDE VIEW SKETCH OF DUST-STORM.

A special dust-weigher designed by the Instruments section of the India Meteorological Department was used and the R.A.F. wireless tower at Peshawar, fitted with a number of platforms, enabled the writer to obtain readings at various heights. It was assumed that counting the particles of a fair sample by weight and the adoption of a mean weight per particle would be sufficiently accurate to give the number of particles in the total quantity collected. Unfortunately samples taken from the same collection of dust gave widely different results. Actually, the size of the particles was found (by means of a microscope) to vary mainly between 10^{-4}cm. radius to 10^{-1} cm. radius and the number from several thousands per c.c. to a few millions per c.c.—about 50 per cent. being of the order 10^{-2} cm. For various reasons it was possible to make observations in only five duststorms at heights ranging from ground level to 50 feet. In all cases the dust reached much greater heights—in one instance to over 2,000 feet as observed from the air. Although the task is neither a pleasant nor an easy one, it is hoped that some enthusiastic meteorologist will carry out the investigation attempted by the writer—but with more success. A side view sketch of a duststorm made by the writer is given in Fig. 1. Arrows indicate the probable air motion. The fine sketches of duststorms made many years ago by Baddeley (8) are also worthy of note.

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The Distribution of Pressure and the Drought of 1938

By C. E. P. BROOKS, D.Sc.

In *The Times* for May 14th Mr. A. A. Lea refers to the high pressure area in the north-eastern Atlantic and adjoining coasts which was the immediate cause of the spring drought and asked if meteorologists could say why depressions were kept at a distance from the British Isles for so long.

In attempting an answer to Mr. Lea's question it is necessary first to consider the normal distribution of pressure over the North Atlantic, the Arctic Ocean and the neighbouring parts of Europe and Siberia and then to examine the differences from this normal distribution during the early months of 1938.

The normal pressure distribution in winter and spring in the wider neighbourhood of the British Isles is governed by three main " centres of action," namely, an anticyclone over the Azores, an anticyclone over Siberia and a low pressure area in the neighbourhood of Iceland. The two anticyclones are fairly stable but the Icelandic low represents the focal point of a continuous series of depressions travelling from a westerly to an easterly point. Pressure normally rises from Iceland towards the Arctic Ocean and the main track of the depressions lies near 60° N. latitude.

The Arctic Ocean carries a mass of floating ice which under the normal light and irregular winds of that region is spread over almost the whole ocean. This forms a cold surface above which the air is cold and stable.

Over the British Isles the isobars run roughly from WSW. to ENE. but they are constantly disturbed by secondary depressions and fronts associated with depressions near Iceland and occasionally by primary depressions following a more southerly track. These disturbances bring our usually abundant rainfall.

The type of disturbance of these normal conditions which most commonly leads to drought over the British Isles can be simply described as a shift of the whole system towards the north-east. The Azores anticyclone advances towards the British Isles giving high pressure and fine anticyclonic weather, while at the same time the tracks of the depressions follow unusually high latitudes. This implies that the southern boundary of the cold stable air mass over the Arctic Ocean in the region of Europe and western Siberia also lies unusually far north. Since the cold air mass is to some extent a product of the floating ice, we should expect the southern boundary of the Arctic ice also to lie unusually far north.

Floating ice is driven by winds and currents but a large and relatively flat sheet requires prolonged winds from one direction to set it in motion. The maps of pressure, and of deviation of pressure from normal, drawn for the northern hemisphere each month in the Meteorological Office, based on the "Climat" messages* broadcast early in the following month, show that throughout January, February and March, 1938, the pressure distribution over Europe, Siberia and the Arctic was such that abnormally persistent southerly winds prevailed on the north coast of Europe and western Asia. This southerly current of air drove the ice northward, with the result that high temperature and low pressure prevailed over the Arctic during February, March and April. High pressure and drought over the British Isles during these months was the natural corollary.

We still have to account for the southerly winds in the Arctic, and this, at present, we are unable to do. Conditions in any area in any month follow in a highly complicated way from preceding conditions over a large part if not the whole world, while changes in the sun and terrestrial "accidents" such as volcanic eruptions may also play a part. At present the problem presented by these relationships is very far from being solved, and it is possible only to give a very partial answer to Mr. Lea's question.

Royal Meteorological Society

A meeting of the Society was held on Wednesday, May 18th, in the Society's rooms at 49, Cromwell Road, South Kensington. Dr. B. A. Keen, F.R.S., President, was in the Chair.

The following papers were read and discussed.

R. Moss.—Atmospheric optical phenomena in North East Land.

A record is given of the various atmospheric optical phenomena observed during the ten months' occupation of a station on the inland ice of North East Land (80° N., 20° E.) by the Oxford

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* See *Meteorological Magazine*, 72, 1937, p. 105.

University Arctic Expedition, 1935–36. As well as the more common mock suns and mock moons several complexes were observed, notably on June 6, 1936, when the comparatively rare Parry arc occurred. There were also many instances of a phenomenon which has occasionally been described previously but which has not been distinguished from others, with which it usually occurs simultaneously. It takes the form of a pair of *white* mock suns on or near the visible horizon: they do not appear to be essentially connected with the usual "prismatic" halo phenomena. The name "hypohelia" is proposed for them.

Miss M. M. Paranjpe, Ph.D.—The variations of the solar constant and their relation to weather.

The determinations of the solar constant obtained by the Astrophysical Observatory of the Smithsonian Institute during the last thirty years are discussed, with results which point to the conclusion that the observed variations are mainly due to the defects in the methods of determining the solar constant. If this conclusion is accepted the subsequent work based on the supposed variability of the solar constant is not valid.

A. F. Crossley, M.A.—Notes on the variation of pressure accompanying a distortion of air flow.

It is known that certain meteorological stations frequently record a mean-sea-level pressure which is lower than that which would be expected from the general run of the isobars by amounts up to about one millibar. These stations are located in over-exposed situations, such as the tip of a promontory, where the wind speed may be appreciably in excess of the speed in an ideal exposure. In steady motion, the flow of wind over or round the promontory conforms with Bernoulli's equation, which gives a relation between pressure and velocity at points on the same stream line. It is shown that a reasonable increase of wind speed above normal produces a decrease of pressure of the right magnitude. The equation is applied in the first instance to steady frictionless motion, but it is shown that the results apply with little variation to the flow of surface air, as modified by friction.

T. E. W. Schumann, M.Sc., Ph.D., and W. L. Hofmeyr, M.Sc.—The partition of a region into rainfall districts with special reference to South Africa.

A method is presented for dividing any region into a number of rainfall districts on the basis of seasonal distribution of precipitation. This is accomplished by drawing on a map of the region two systems of lines of equal "phase" and equal "relative amplitude," which are measures respectively of the epoch of maximum rainfall and of the normal fluctuation which occurs in the course of a year. A map of the Union of South Africa is reproduced showing rainfall districts obtained by this method.

Correspondence

To the Editor, *Meteorological Magazine*

Divergent Winds

It is good to have Dr. Sutcliffe's reminder of the difference between " divergence " and " fanning out " of winds and isobars but experience certainly suggests a high correlation between the two phenomena and a further note from Dr. Sutcliffe explaining any possible reason for this would be very welcome. It would be useful to know, too, whether the correlation is sufficiently close to justify the assumption in practical forecasting, on occasions when reports of upper air temperatures and winds are scarce, that fanning out is normally accompanied by subsidence.

Just as it is frequently necessary to assume that the 2,000 ft. wind is equal to the gradient wind, so the most accurate forecasts may result from the assumption that fanning out indicates subsidence and the wiping out of cloud and frontal effects.

R. M. POULTER

Meteorological Office, R.A.E., S. Farnborough, Hants., April 7th, 1938.

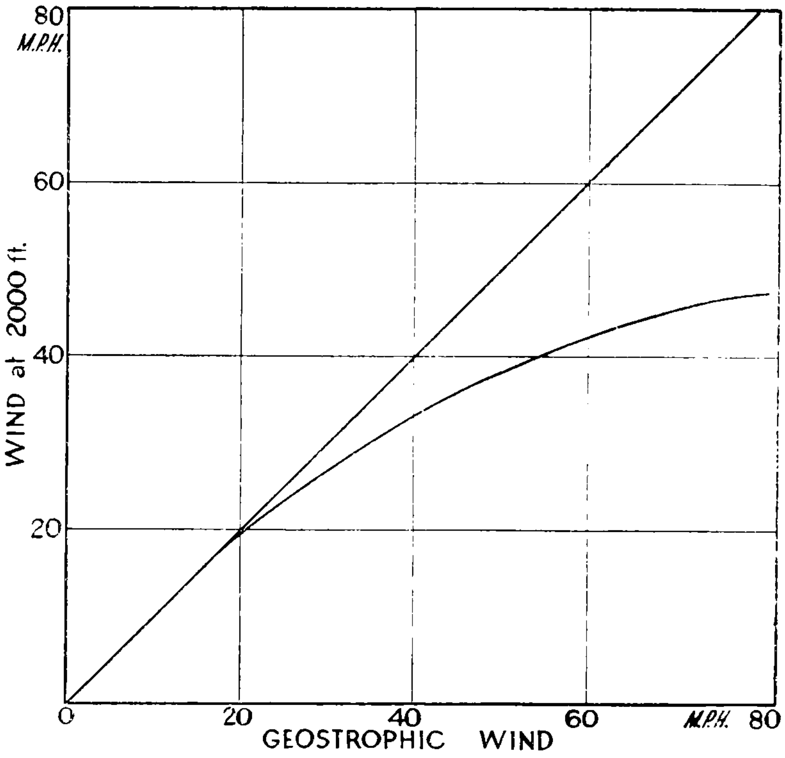
A further remark on Divergent Winds

In the note of similar title in the March issue of the *Meteorological Magazine* it is remarked that " The winds are of course never more than approximately geostrophic and it is the departure from the geostrophic value which determines all divergence. . . . . The effect of spreading isobars upon the geostrophic departure is not difficult to determine with certain approximations.". This is true. Upon the approximations used will depend, apparently, not only the quantitative, but also the qualitative, value of the result. I have investigated the effect of fanning isobars and find, assuming an unchanging pressure distribution and gradient winds, that the convergence of the air depends entirely upon the quantity $\nabla\left(\frac{1}{rd}\right)$ where r is the radius of curvature of the path of the air (i.e. of the isobars), regarded as positive for cyclonic motion, and d is the distance apart of the isobars.

If we regard r as constant we obtain the result that, with fanning isobars (that is isobars spreading out in the direction of the flow) there will be divergence with cyclonic motion, convergence with anticyclonic motion.

In the particular case in point the curvature of the isobars appears to be cyclonic over most of the British Isles, and hence we should expect there to be divergence. The extent to which this result will be affected by changes of curvature is not easy to estimate, but since r appears to decrease the amount of divergence will be reduced. It is generally found, however, in actual trajectories, that the curvature remains practically constant.

This theoretical discussion gives a result seemingly in accordance with observations, but there is a second, more practical, way of looking at the problem.



The figure shows the result of comparing, for a great number of winds from between S. and W., the actual wind at 2,000 ft.. as found by pilot balloons, and the geostrophic wind as measured from a working chart. It was found that, as is already well known, the actual wind was, almost without exception, less than the geostrophic wind ; the graph shows that the difference between the two is greater, even proportionately, for high speeds than for low.

Accepting this fact then it is clear that a fanning of the isobars would, in fact, give rise to divergent winds.

Quantitatively, under the conditions illustrated in Fig. 1 of the leading article of the December, 1937, issue of this magazine the divergence is of small order. In either of the above theories the divergence is such that, if reversed to become convergence, it would give rainfall at the rate of, very roughly, 0·001 mm. per hour.

The article referred to gives no clue as to where, if anywhere, the pleasant weather was particularly evident. Nor does a cursory glance through the *Monthly Weather Reports* do more in this direction than cause one to express mild surprise that a period of six months of which one is reported to have had a " marked deficiency " of sunshine, two to have had a " general deficiency", two to have been " average " and one only to have " exceeded the average", could be described as a period of " pleasant weather".

RONALD FRITH

Meteorological Office, R.A.F., Hemswell, Lincs., March 29th, 1938.

[Dr. Frith starts a new hare in the last paragraph of his letter. I will only remark that in defining pleasant weather dryness and warmth surely count for as much as sunshine, and June to October, 1937, were very dry in England and warm on the whole. The passage criticised, however, referred to the weather generally characteristic of the type of pressure distribution illustrated, of which 1937 was admittedly not so good an example as say 1921 or 1933. The favourable conditions are best developed in southern England and neighbouring parts of the continent, and it seems hard to escape from the logical conclusion that there is a certain amount of subsidence in this district. C. E. P. BROOKS.]

The Aurora of May 11th—12th, 1938

An auroral display was observed from here between 23h. 40m. and 23h. 55m. G.M.T. last night (May 11th). From a point to the SE. and at an elevation of 80°, brilliant white streamers radiated to the sector of the horizon between north and north-east; one streamer from the north-east continued right across the sky to the south-west. Between the streamers the sky glowed rosy pink and this was actually the first phenomenon observed. The time between the first appearance and the final disappearance of the streamers was only 8 minutes, after which the pink glow slowly faded. The remarkable feature of the display was that the whole illumination was confined to the sector of the sky between north and north-east, with the exception of the streamer from north-east to south-west, passing west of the moon. There was about seven-tenths of cirrus at the time.

G. THORNTON SMITH

Meteorological Office, R.A.F., Hucknall, Notts., May 12th, 1938.

I am sending a short description of the Aurora which I saw round about 1h. this morning.

At about 0h. 55m. I first observed two bright carmine patches of haze in the sky. The smaller seemed to be over Leith Hill Tower. The larger, high overhead, had a whitish green extension towards the north-west and developed long parallel whitish streaks across the red. After about four minutes the Leith Hill patch and the streaks had faded, and a red glow spread in one large hazy cloud effect directly overhead. This seemed now to be much nearer the ground. Later, another patch appeared over towards Peaslake. This condition continued till about 1h. 5m. when I ceased to observe the phenomenon. I noticed a pronounced "electric feeling", as before a thunderstorm.

MILDRED SLOW.

Abinger Hill School, near Dorking, Surrey, May 11th, 1938.

The following notes on the aurora have been forwarded by Mr. J. H. Dyson of Preston, Canterbury :—

Auroral activity first suspected at 2330 B.S.T., when a belt of pale radiance, faintly luminous, was discernible to the north at approx. 30° elevation.

2330–0000 :—Steady increase of activity.

0000 B.S.T. (approx.) :—General brightening of the display, with splashes of white light low to NNW. : formation of low, flat arch, NW. to NNE., of approx. 30° elevation, with a few, faint rays.

0026–0034 :—Rays and streamers, rather faint, elevation 30°–40°N. Pale luminosity NW.–NE. Above arch, sky faintly tinged with rose : arch becoming curved, increased to 35°–40° NNW.

0034–0040 :—Elevation of arch 40° NNW. Increased activity to NNW. and NNE., with pale rays and streamers : sky at 60° pale rose purple, especially to NNE.

0040–0042 :—Increased activity : becoming brilliant. Bright rays NW.–NE., and crowned by deep, blood-red tint.

0042–0046 :—Brilliant Aurora. Blood-red at 80°, W. across to NE., flaming at intervals. Equal to Jan. 25th–26th.

0046–0056 :—Brilliant "flame" aurora moving slowly from WNW., of blazing carmine, elevation 90° : multi-coloured rays : superb display W. to ENE., with bright rays extending to zenith : southern half of sky tinged by reflection with peculiar green of weathered copper.

0056–0101 :—Blood-red W.–NE., extending to zenith.

0101–0113 :—Display fading : general rose pink above 30° elevation, and pale copper green below. A few rays.

0113–0115 :—Pink fading out : a few pale streamers to NW. and N.

0115–0119 and after :—A few pale streamers moving from N. to NW at 20° elevation : red coloration faded out, except for a tint of rose at N. 40°.

A Green Moon.

In the November issue of the *Meteorological Magazine*, Dr. F. J. W. Whipple wrote about the phenomenon of a "green moon." In Inverleith Park on Wednesday, November 24th, at 8h. 15m. a similar moon was visible at an elevation of about 35°. The moon was twenty-one days old, the last quarter being on the 25th. At 7h. the sky was cloudless and the visibility was 7. The sun rose at 7h. 34m., and at 8h. 15m. a small cirro-cumulus-lenticularis and some alto-cumulus had developed. The moon was covered by a thick cloud, as on October 16th, which I think was alto-cumulus.

It seems that since the conditions of atmosphere were quite normal, the explanation which Dr. Whipple gives for this phenomenon adapts itself equally well to both observations, that is, that it was the result of a contrast. The illumination of the sun on the clouds round the moon had produced this odd effect, such that the pure white moon seemed green. On October 16th the phenomenon was observed about twenty minutes after sunset, and on November 24th it was observed about forty minutes after sunrise. But the elevation of the moon was different and may cancel out the difference in time. And perhaps the effect of the risen sun's illumination on clouds at an elevation of 35° is similar to that of a set sun on clouds at 20°.

Unfortunately, I was unable owing to hurry to observe the subsequent changes in colour through which the moon passed, but the facts which I have given may be of interest to others who have observed this phenomenon. FERGUS MACPHERSON.

7, Wardie Crescent, Edinburgh, December 11th, 1937.

Snow Notes for Winter, 1937—38

In view of the increased interest now being taken in the snow conditions of the British Isles perhaps the following notes may not come amiss. The state of things described must not be taken as normal for the mildness and absence of precipitation in the second half of the winter is without precedent. Observations were noted at three stations, viz. at 2,300 ft. on ridge of the Black mountains separating Hereford from Brecon, 12 miles distant; at 1,300 ft. just over the Monmouth border, 2 miles distant, and in a valley here 200 ft. above sea level.

In October and November there was no snow lying at any station ; in December there was snow lying at 2,300 ft. on 20 days (and including patches, 30 days) ; at 1,300 ft. on 9 days ; in valley on 3 days, or rather parts of days, and never as much as ½ inch deep, which snow fell on 5 days. In January at 2,300 ft. on 6 days (and including drifts left from December on about 13 days), at 1,300 ft. on 1 day and in valley no days. Snow fell 1 day. In February at 2,300 ft. on 3 days (no drifts) ; at 1,300 ft. on 2 days, in valley no days, snow fell on 3 days. Since February 18th there has not been a speck of snow even at 2,600 ft. and precipitation for the month was only 0·74 (of which about 0·10 was snow at 2,300 ft.). March was the driest March on record, the rainfall being only ·025 (·005, ·01 and ·01), while April up to 21st has only provided 0·05. Ben Nevis, which in mid-April should have a covering of 10 ft. of snow, has only a few patches on the summit. In the 51 days March 1st–April 20th we have only had 0·08 rain and the anticyclone shows no signs of collapsing. Is it possible that sun spots—I saw 5 large ones a few days ago—have upset the normal circulation of the atmosphere and have caused this extraordinary persistence of anticyclonic conditions over Britain ?

The late R. P. DANSEY.

Kentchurch Rectory, Nr. Hereford, April 21st, 1938.

NOTES AND QUERIES

Observations at the Radcliffe Meteorological Station, Oxford, in the years 1931-1935.

An article entitled " The Swan Song of the Radcliffe Observatory," published in the *Meteorological Magazine* for September, 1932, contained an appreciation of the five-yearly volumes of observations published by the Trustees of the Radcliffe Observatory. In particular, praise was bestowed upon the Appendix to the last volume (1926-1930) in which was given a homogeneous set of serial monthly values for each element going back to the earliest date for which comparable data were available. In the case of dry bulb temperature and rainfall the observations went back to 1815. When the article was written it was feared that, with the removal of the Radcliffe Observatory from Oxford, the publication *in extenso* of the meteorological results would cease, although strenuous efforts were being made to provide for the continuance of climatological observations in Oxford. In these circumstances it is a very great pleasure to record the publication of a volume entitled " Results of Meteorological Observations made at the Radcliffe Meteorological Station, Oxford, in the five years 1931-1935." We learn from the Introduction that the station remained under the control of the Radcliffe Observer, Dr. H. Knox Shaw, until June 1935. In 1935 the Radcliffe Trustees presented all their meteorological instruments to the University of Oxford and in addition undertook to pay the salary of a full-time observer. The Observatory buildings have become the Nuffield Institute of Medical Research but the Nuffield Trustees have allowed the meteorological instruments to remain in nearly the same positions as they occupied in previous years. The enclosure containing the earth thermometers and the Stevenson screens which house the thermometers and the thermograph was moved on January 1, 1935 to a position 60 ft. SSW. of the old position. It now stands in the middle of the lawn as is shown in the photograph on the title page of the volume ; the old position was on the edge of the same lawn a few yards to the west of the main porch of the Observatory buildings. The enclosure was widened to 18 feet and now contains, in addition to the Stevenson screens and the earth thermometers, the grass minimum thermometers and the rain-gauges. The University has delegated the control for administrative purposes to its School of Geography with Mr. W. G. Kendrew in charge. It is most satisfactory that so long a series of meteorological observations can go on unbroken.

The tables in the new volume differ in some respects from those in the previous publications. In order to reduce expense certain columns have been omitted from the daily values, namely, the 9h. values of dry and wet bulb temperatures, the velocity of the wind, the cloud amount, the visibility and also the daily weather notes. With these omissions two months can be arranged on one page and the book is considerably thinner than the last volume of the Radcliffe Observatory. These observations are still made and the results kept in the manuscript records of the station. Another small difference is that the daily values of the underground temperature and the notes on occasional phenomena are grouped together for the five years instead of being placed at the end of the corresponding year. Near the end of the volume is a section giving the summary of monthly values for each element in continuation of similar figures in the Appendix to " Results of meteorological observations made at the Radcliffe Observatory, Oxford, in the five years 1926–1930." A useful new table giving the mean monthly underground temperatures at 1 foot and 4 feet at 9h. for the years 1925–1935 has been added to this summary.

Some interesting records were established in the five-year period 1931–35. The month December, 1934, was particularly interesting ; the mean pressure 29·354 in. is the lowest on record for December, while both the mean maximum and mean minimum temperatures, 50·8°F. and 42·7°F., are the highest on record. The absolute maximum temperature in August 1932, namely, 95·2°F. is the highest temperature that has been recorded in any month, while May 1932 is distinguished as being the dullest as well as the wettest May on record.

In the final section new tables of period means are given for pressure, number of rain-days, sunshine, wind velocity and wind direction.

L. F. LEWIS.

" WIXFW "

An article entitled " WIXFW " by C. F. Brooks in the *Harvard Alumni Bulletin*, July 2nd, 1937, describes progress made during the preceding two years in upper air observations by radio sondes.

Early in 1937 a series of ascents was made to test the reliability for routine soundings of the radio-meteorograph developed at Harvard. Of 31 ascents, 27 gave records up to 17,000 ft. or more, the average being 44,000 ft. The best was a record of all elements (pressure, temperature and humidity) up to 79,000 ft.

The method by which the values of the elements are signalled is as follows :—

A small cylinder of electrically insulating material is turned by clockwork at 1 revolution in half a minute. On the cylinder is wound a helix of four turns of platinum wire. Four light styles make contact at different parts of the helix once in each revolution. One of the styles is fixed, the other three being carried by the meteorological instruments, aneroid, bimetallic thermometer and hair hygrograph. As the values of the elements change the styles move parallel to the axis of the cylinder, so that the contacts occur at varying time intervals after those of the fixed style. Each contact sends out a signal, which is amplified by the receiver and recorded by a marker which moves across a sheet of paper. The dots form curves, one for each of the three elements ; the distance of each curve from the straight base line, interpreted by a calibration curve, is a measure of the element.

The meteorograph costs about 18 dollars, and the total cost of an ascent is less than 25 dollars. Even if the instrument is lost every time, this is less than the cost of an aeroplane ascent to a height comparable with that reached by the meteorograph.

D. N. HARRISON.

REVIEWS

Hurricanes, their nature and history. Particularly those of the West Indies and Southern Coasts of the United States. By Ivan Ray Tannehill. Size 9 in. × $6\frac{1}{4}$ in., pp. x + 257. *Illus.* Princeton, Univ. Press and London, Oxford Univ. Press, 1938. Price 3·50 dollars net.: 16s. net.

In connection with the establishment of hurricane warning stations by the U.S. Weather Bureau in the West Indies during the Spanish-American war, the author of this book quotes President McKinley as saying that he was more afraid of a West Indian hurricane than of the entire Spanish navy. In earlier wars hurricanes have scattered and sunk navies and troop ships, while in times of peace the total losses amount to many thousands of lives and uncounted material wealth. The Chief of the Marine Division of the U.S. Weather Bureau is therefore writing of a subject of great human and economic importance, and as he is able to draw freely on his own long experience and the vast storehouse of information at his command, he has produced a notable contribution to meteorological literature.

The opening half of the book is mainly descriptive. The first chapter deals with the structure of the hurricane, and is illustrated by reproductions of autographic records showing the "eye" and some remarkable descriptions of this central calm and of the violent winds which surround it. Then follows a very good account of the accompanying great storm waves which have been responsible for some appalling catastrophes, and constitute the greatest danger to life in coastal towns of the hurricane regions.

The origin of hurricanes has been a matter of some controversy between the adherents of the older convectional and the newer frontal theory. It is generally difficult to obtain sufficient observations during the early stages of a storm, but the author is able to discuss in considerable detail one which originated in the Caribbean in 1926, and he shows that instead of growing from a small whirl it developed gradually over a considerable area. In a very detailed account of tracks in different months, and in a later chapter on unusual hurricane movements, he is able to show how both normal and aberrant tracks can to some extent be accounted for by considerations of land and sea distribution and by neighbouring pressure systems.

Chapters V and VI deal with the heavy rainfall of tropical cyclones and barometric pressures in the centre. Several readings below 27 inches are known, but there is some doubt about most of these, though the figure of 26·185 inches quoted from the *Meteorological Magazine* for February 1933 appears to be accurate. The signs of an approaching hurricane are next described, especially storm swells, which are explained in detail. The descriptive part ends with chapters on the destructive effects of hurricanes, illustrated by some very striking photographs, and precautionary measures.

The second half of the book is historical. The final chapter gives a chronological list of several hundred West Indian hurricanes from 1494 to 1900, with brief remarks, and many of these are described in greater detail, particularly as regards damage and loss of life, in preceding chapters. Information about the earlier hurricanes is naturally scanty, but more or less accurate mapping of tracks becomes possible for storms towards the close of the 19th century, the first tracks illustrated here being those of three historical storms in 1790. With the twentieth century the documentation becomes much more complete, and from 1901 onwards the hurricanes are described and illustrated year by year. Of the 919 listed in the book, no fewer than 249 came in the years 1901 to 1937. The historical part of the book deals only with West Indian hurricanes; it forms a most valuable addition to the meteorological literature of the North Atlantic. The work ends with a comprehensive bibliography. The whole is excellently produced and abundantly illustrated, and there is a good index. C. E. P. Brooks.

Climatic Notes: New Zealand Districts. By Dr. E. Kidson. Meteorological Office Note No. 17. pp. 1–32. Wellington, 1937.

This paper forms No. 17 of a series of notes dealing with different aspects of the climate and weather of New Zealand, which have been published since 1931 by the Meteorological Office in Wellington. The present note has been prepared primarily for use by agriculturists in connection with soil-surveys. The paper is in two parts in both of which the same general arrangement is followed. The first part deals with the climate of Hawke's Bay and the second with that of North Auckland.

The elements discussed include temperature, frost, rainfall, humidity, sunshine and wind. Except in the case of rainfall the data available are somewhat scanty and are limited to observations from not more than six stations in each district and for some elements from only two. For rainfall the information is much more detailed. Charts are reproduced of the mean annual fall and of the number of rain-days and these are supplemented by tables of the average monthly fall at more than 80 stations, for the majority of which the average number of rain-days per month is also included.

Tables indicating the variability of the rainfall are a valuable feature of the paper. They show first the extreme monthly falls at some 60 stations for which long records are available, secondly the percentage frequency of monthly falls between different limits at stations grouped together according to their annual rainfall, and thirdly a table of the rainfall in each year expressed as a percentage of the normal. The practice of indicating the variability in this way might well be followed by meteorologists more widely than it is ; a knowledge of the extremes to which the rainfall is liable is all-important for an agriculturist.

BOOKS RECEIVED

Squalls at Karachi. By P. R. Krishna Rao. India Met. Dept. Sc. Notes VII, 75. Delhi, 1938.

Onweders, optische verschijnselen, Enz. in Nederland. Naar vrijwillige waarnemingen in 1935. Deel LVI. De Bilt 1937.

Ergebnisse Aerologischer Beobachtungen 25, 1936 and *Jaarboek, A. Meteorologie B. Aardmagnetisme* 1936. K. Ned. Meteor. Inst. (Nos. 106A, 97 and 98). De Bilt, 1937.

OBITUARY

We regret to learn of the death in Buenos Aires on 10th January at the age of 68 of Mr. George O. Wiggin formerly Director (1915–1924) of the Oficina Meteorológica Argentina.

Mr. Wiggin took an active part as chief assistant to Mr. W. G. Davis (Director 1885–1915) in the great development in the above service at the beginning of the century.

We regret to learn of the death of the Rev. R. P. Dansey, of Kentchurch Rectory, Hereford, who died suddenly on April 27th, 1938. Mr. Dansey maintained a regular rainfall record there since 1906 and took a great interest in meteorology, frequently forwarding details of his weather observations to the Office. Of his numerous contributions to this Magazine mention may be made of the following :—The Glacial Snow of Ben Nevis (1905, pp. 29–32) ; The extraordinary warmth of January, 1916 (1916, p. 8) ; June in the Pyrenees (1912, pp. 141–5) ; Corsica in May (1915, pp. 47–9) ; The Snowless winter of 1924–5 (1925, pp. 139–140) ; The hot summer and Scottish snowbeds (1933, pp. 238 and 259) and Snow in June (1936, 159). Living near the Black Mountains of Breconshire, Mr. Dansey had opportunities of studying the incidence and distribution of snow, a subject in which he was keenly interested. His notes on the snow of the winter 1937–8 are included in this number (page 123).

We regret to learn of the death on June 6th, 1938 of Professor Dr. Hugo Hergesell, for many years Director of the Aeronautical Observatory, Lindenberg.

ERRATA

Climatological Tables, 1937

Lagos—July. Pressure diff. from normal *for* +1·7 *read* +0·9.

Mauritius—Jan. Rainfall diff. from normal *for* +1·96 *read* +2·36.

Mauritius—Feb. Rainfall diff. from normal *for* —2·42 *read* —3·31.

Singapore—March. Rainfall diff. from normal *for* —0·47 *read* + 0·47.

Sandakan—Feb. Rainfall diff. from normal *for* —6·39 *read* — 5·39.

Victoria, B.C.—Feb. Rainfall diff. from normal *for* +1·97 *read* — 1·97.

The Weather of May, 1938

The Azores anticyclone was well developed, and extended northward in a long ridge (above 1015 mb.) across Greenland to Spitsbergen. Pressure was 4 mb. above normal in the Azores and 6 mb. above in southern Greenland. There was a shallow depression (about 1012 mb.) from western Scotland across Scandinavia, but over most of Europe the distribution was remarkably uniform, about 1015 mb., and differed little from normal. The low pressure area over northern India was unusually vigorous, the means of 998 mb. being 4 to 5 mb. below normal. Pressure was also deficient (—5 mb.) in a depression over Alaska but elsewhere in North America it differed little from the average. Temperature was again above normal in the Arctic, by 3° F. in Spitsbergen, and by more than 5° F. in north-west Siberia but most of Europe south of 60° N. was several degrees colder than normal, the deficiency exceeding 5° F. in most of Italy and the Balkans. The British Isles differed little from normal except in the south-east (—2° F.). In northern India temperatures exceeded 90° F. and were 4° F. to 7° F. above normal, but western India and Burmah were cool (Mandalay —6° F.). In North America the differences were small. Rainfall was very variable; some heavy falls were recorded locally—nearly 8 inches at Marseilles and Venice, and 4 to 5 inches in parts of south-eastern Europe. In India the rainfall was generally light except in the west (Rangoon 17 in., Calcutta 15 in., Mandalay 13 in.) where it was much above normal. North America differed little from average except for the Pacific coast, where rainfall was deficient.

Over the greater part of Australia pressure was slightly below normal, but south-east Australia and New Zealand showed an excess, reaching 5 mb. in the central regions of New Zealand. Temperature was generally slightly above normal and rainfall deficient, but heavy falls were experienced in some places (Adelaide 12 in., Norfolk Island 9 in.).

In contrast to the exceptional drought experienced in the three months February to April, rainfall in May was excessive over the British Isles as a whole. Sunshine was deficient generally in Ireland, England and the north-east of Scotland ; an excess was recorded, however, at numerous places elsewhere in Scotland and in parts of northern England. The month was cool in some districts, particularly the south and east of England.

During the opening days of the month an anticyclone moved slowly westward from the north-east of Scotland to the south of Iceland. Meanwhile pressure was relatively low over France and a depression off south-west Ireland moved south-east to Spain. Weather was fair and sunny in the north but rain fell locally at times in England and the extreme south of Ireland. Some good daily records of bright sunshine were registered during this period ; 14 hours or slightly more were registered at some place or other on each of the first five days and at Tiree, in the Inner Hebrides, the total for the four days 2nd–5th was 57·8 hours. On the other hand, at Croydon the total for the first four days was only 3·8 hours. Thereafter pressure was low over Scandinavia and high westward of the British Isles. Polar air caused a considerable fall of temperature on the 7th, and showers occurred, mainly in northern Scotland and on the east coast of Great Britain ; snow and hail were reported in Scotland on the 7th. On the 8th and 9th a depression south of Iceland moved east-south-east to southern Norway causing precipitation, chiefly in Scotland, the north of Ireland and north-east England. On the 10th a wedge of high pressure passed east over Great Britain. Subsequently pressure was high over central Europe, while Atlantic depressions moved north-east ; rain fell, chiefly in the west and north, and was somewhat heavy in places on the 11th and 13th ; 1·12 in. was measured at Waterford on the 13th. A period of unsettled weather ensued with depressions moving directly over the British Isles ; scattered thunderstorms occurred daily from the 14th–18th and fairly heavy rain was recorded locally ; for example, 1·54 in. at Edinburgh on the 15th, 1·65 in. at Barningham Park, Yorkshire on the 16th and 1·77 in. at Cranwell on the 17th, of which 0·95 in. fell in 48 minutes. It was warm generally on the 14th and temperature rose to 79° F. at Norwich and Herne Bay and 76° F. at Margate and Tottenham. On the 19th and 20th a belt of high pressure moved eastward over the country; sunshine was good in many parts, but rain was recorded locally in eastern districts of England and in Ireland and the extreme south-west of England. A trough of low pressure moving north-east over the north-western districts of the British Isles gave rain in Scotland and Ireland on the 21st. Subsequently from the 23rd–31st, Atlantic depressions passed over the British Isles and unsettled weather prevailed. Rain fell frequently and local thunderstorms were recorded on the 24th, 27th, 28th and 30th. Among the heavier falls of rain in 24 hours were 1·59 in. at Montgomery on the 27th, 1·26 in. at Edinburgh on the 28th and 1·62 in. at St. Helens, Lancs., and 1·49 in. at Warrington on the 29th. Gales occurred locally in England from the 29th–31st.

The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ..	209	+30	Chester ..	168	+ 2
Aberdeen ..	147	−23	Ross-on-Wye	143	−43
Dublin	140	−40	Falmouth ..	168	−39
Birr Castle ..	147	−22	Gorleston ..	165	−58
Valentia ..	154	−30	Kew.. ..	161	−37

Kew, Temperature, Mean, 52·5°F, Diff. from average −2·0°F.

Miscellaneous notes on weather abroad from various sources.

Rain, accompanied by violent hailstorms, fell incessantly for 6 days in eastern Spain, until May 3rd. The drought in Switzerland which had lasted 70 days was broken on the 3rd. Heavy rain on the 8th caused flooding in parts of Lisbon. After a period of unseasonably cold, dry weather temperatures rose in Germany on the 15th, when 84·2°F. was recorded in Berlin; 10,000 acres of woodland between Bremen and Hanover were destroyed by fire on the same day. Heavy rain and the sudden thaw in the mountains caused the flooding of the River Mur on the 21st. Eleven people were drowned and over 300 rendered homeless in Syria and Carinthia. Intense cold swept over France and Switzerland on the 21st and 22nd, and snow fell down to the 1,500 ft. level. All the Alpine passes were blocked, but the Simplon was reopened on the 22nd. Thick fog was reported from Cherbourg on the 23rd. A breach in the Skeidarar Glacier in south-east Iceland on the 25th caused floods which interrupted all traffic and swept away telegraph wires. A cloudburst was reported from Budapest on the 29th. (*The Times*, May 4th–30th.)

A violent storm and a waterspout on the 4th destroyed 50 houses and caused 5 deaths in Antioch, Syria. (*The Times*, May 6th.)

The "long rains" broke throughout Kenya on the 6th, and continued with such force that floods occurred, interrupting railway

Rainfall : May, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.
Lond.	Camden Square	1·43	81
Sur.	Reigate, Wray Pk. Rd.	1·91	105
Kent.	Tenterden, Ashenden	2·67	170
,,	Folkestone, Boro. San.	3·17	...
,,	Margate, Cliftonville	1·81	115
,,	Eden'bdg., Falconhurst	2·65	142
Sus.	Compton, Compton Ho.	2·35	106
,,	Patching Farm	2·04	110
,,	Eastbourne, Wil. Sq.	2·37	143
Hants.	Ventnor, Roy.Nat.Hos.	1·29	76
,,	Southampton,East Park	2·02	101
,,	Ovington Rectory	1·95	90
,,	Sherborne St. John	1·52	78
Herts.	Royston, Therfield Rec.	2·11	109
Bucks.	Slough, Upton	1·81	108
Oxf.	Oxford, Radcliffe	1·97	105
N'hant	Wellingboro, Swanspool	1·68	87
,,	Oundle	2·22	...
Beds.	Woburn, Exptl. Farm	1·77	91
Cam.	Cambridge, Bot. Gdns.	1·94	110
,,	March	1·97	114
Essex.	Chelmsford,County Gdns	1·72	119
,,	Lexden Hill House	1·42	...
Suff.	Haughley House	1·83	...
,,	Rendlesham Hall	2·27	150
,,	Lowestoft Sec. School	1·94	120
,,	Bury St. Ed., WestleyH.	2·07	114
Norf.	Wells, Holkham Hall	1·22	76
Wilts.	Porton, W.D. Exp'l. Stn	1·68	98
,,	Bishops Cannings	1·85	95
Dor.	Weymouth, Westham.	1·13	70
,,	Beaminster, East St.	2·88	140
,,	Shaftesbury,Abbey Ho.	1·95	92
Devon.	Plymouth, The Hoe	3·05	147
,,	Holne, Church Pk. Cott.	5·54	175
,,	Teignmouth, Den Gdns.	2·34	128
,,	Cullompton	2·52	117
,,	Sidmouth, U.D.C.	1·89	...
,,	Barnstaple, N. Dev.Ath	2·07	100
,,	Dartm'r,Cranmere Pool	5·20	...
,,	Okehampton, Uplands.	2·80	104
Corn.	Redruth, Trewirgie	3·39	147
,,	Penzance, Morrab Gdns.	2·84	129
,,	St. Austell, Trevarna	4·01	166
Soms.	Chewton Mendip	2·41	87
,,	Long Ashton	2·19	104
,,	Street, Millfield	2·07	111
Glos.	Blockley	1·91	...
,,	Cirencester, Gwynfa	2·54	123
Here.	Ross-on-Wye	1·88	88
Salop.	Church Stretton	2·70	105
,,	Shifnal, Hatton Grange	1·32	64
,,	Cheswardine Hall	2·15	97
Worc.	Malvern, Free Library	2·07	96
,,	Ombersley, Holt Lock.	1·48	72
War.	Alcester, Ragley Hall	2·12	103
,,	Birminghm, Edgbaston	1·84	86
Leics.	Thornton Reservoir	1·89	94
,,	Belvoir Castle	2·83	134
Rut.	Ridlington	1·87	93
Lincs.	Boston, Skirbeck	2·06	117
,,	Cranwell Aerodrome	4·13	228
,,	Skegness, Marine Gdns.	2·36	139
,,	Louth, Westgate	2·03	100
,,	Brigg, Wrawby St.	2·45	...
Notts.	Mansfield, Carr Bank	2·92	138
Derby.	Derby, The Arboretum	1·72	86
,,	Buxton, Terrace Slopes	4·39	142
Ches.	Bidston Obsy	2·66	140
Lancs.	Manchester, Whit. Pk.	3·43	162
,,	Stonyhurst College	3·63	127
,,	Southport, Bedford Pk.	3·50	167
,,	Ulverston, Poaka Beck	4·35	137
,,	Lancaster, Greg Obsy.	3·47	140
,,	Blackpool	2·79	128
Yorks.	Wath-upon-Dearne	2·50	123
,,	Wakefield,Clarence Pk.	2·87	146
,,	Oughtershaw Hall	4·53	...
,,	Wetherby, Ribston H.	...	...
,,	Hull, Pearson Park	3·17	164
,,	Holme-on-Spalding	3·07	152
,,	Felixkirk, Mt. St. John.	3·47	185
,,	York, Museum Gdns.	3·35	168
,,	Pickering, Houndgate	2·99	153
,,	Scarborough	2·45	128
,,	Middlesbrough	2·97	155
,,	Baldersdale, Hury Res.	4·11	159
Durh.	Ushaw College	3·69	171
Nor.	Newcastle, Leazes Pk.	3·68	186
,,	Bellingham, Highgreen	3·05	127
,,	Lilburn Tower Gdns.	2·38	103
Cumb.	Carlisle, Scaleby Hall	3·66	153
,,	Borrowdale, Seathwaite	11·75	170
,,	Thirlmere, Dale Head H.	6·80	143
,,	Keswick, High Hill	3·83	120
,,	Ravenglass, The Grove	4·30	154
West.	Appleby, Castle Bank	2·48	113
Mon.	Abergavenny, Larchf'd	2·22	83
Glam.	Ystalyfera, Wern Ho.	6·32	181
,,	Treherbert, Tynywaun.	7·88	...
,,	Cardiff, Penylan	3·21	131
Carm.	Carmarthen,M. & P. Sch.	4·87	171
Pemb.	Pembroke,Stackpole Ct.	2·53	114
Card.	Aberystwyth	2·48	...
Rad.	BirmW.W.Tyrmynydd	4·83	141
Mont.	Newtown, Penarth Weir	...	...
,,	Lake Vyrnwy	4·54	144
Flint.	Sealand Aerodrome	2·37	129
Mer.	Blaenau Festiniog	6·02	116
,,	Dolgelley, Bontddu	2·71	82
Carn.	Llandudno	1·94	109
,,	Snowdon, L. Llydaw 9	11·05	...
Ang.	Holyhead, Salt Island	2·48	127
,,	Lligwy	2·31	...

Rainfall: May, 1938: Scotland and Ireland

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem	5·08	203	*R&C*	Achnashellach	3·80	85
Guern.	St.Peter P't.Grange Rd.	1·07	63	,,	Stornoway, C.GuardStn.	2·85	117
Wig	Pt. William, Monreith.	3·51	149	*Suth*	Lairg	2·18	86
,,	New Luce School	3·56	125	,,	Skerray Borgie	4·27	...
Kirk	Dalry, Glendarroch	4·81	153	,,	Melvich	3·05	149
Dumf.	Dumfries, Crichton R.I.	4·22	163	,,	Loch More, Achfary	4·27	97
,,	Eskdalemuir Obs	6·19	188	*Caith*	Wick	2·61	126
Roxb	Hawick, Wolfelee	3·30	141	*Ork*	Deerness	3·17	159
Peeb	Stobo Castle	...	...	*Shet*	Lerwick Observatory	4·26	204
Berw	Marchmont House	2·90	117	*Cork*	Cork, University Coll	4·48	198
E.Lot	North Berwick Res	2·90	146	,,	Roches Point, C.G. Stn.	4·18	172
Midl	Edinburgh, Blackfd. H.	4·18	204	,,	Mallow, Longueville	...	...
Lan	Auchtyfardle	3·52	...	*Kerry.*	Valentia Observatory	5·02	158
Ayr	Kilmarnock, Kay Park	3·79	...	,,	Gearhameen	9·30	177
,,	Girvan, Pinmore	2·93	98	,,	Bally McElligott Rec	4·86	...
,,	Glen Afton, Ayr San.	3·92	131	,,	Darrynane Abbey	4·87	163
Renf	Glasgow, Queen's Park	4·70	193	*Wat*	Waterford, Gortmore	4·31	187
,,	Greenock, Prospect H.	3·90	120	*Tip*	Nenagh, Castle Lough.	3·29	133
Bute	Rothesay, Ardencraig	4·63	153	,,	Cashel, Ballinamona	3·96	168
,,	Dougarie Lodge	4·19	152	*Lim*	Foynes, Coolnanes	3·77	162
Arg	Loch Sunart, G'dale	4·60	129	*Clare*	Inagh, Mount Callan	5·03	...
,,	Ardgour House	6·26	...	*Wexf*	Gorey, Courtown Ho	2·68	121
,,	Glen Etive	4·24	85	*Wick*	Rathnew, Clonmannon.	2·54	...
,,	Oban	3·54	...	*Carl*	Bagnalstown, Fenagh H.	2·64	107
,,	Poltalloch	3·69	128	,,	Hacketstown Rectory	2·50	96
,,	Inveraray Castle	7·32	186	*Leix*	Blandsfort House	3·05	126
,,	Islay, Eallabus	3·12	118	*Offaly.*	Birr Castle	3·63	163
,,	Mull, Benmore	8·80	118	*Kild*	Straffan House	2.91	132
,,	Tiree	2·65	106	*Dublin*	Dublin, Phoenix Park	2·52	121
Kinr	Loch Leven Sluice	4·52	185	,,	Balbriggan, Ardgillan	...	...
Fife	Leuchars Aerodrome	4·31	221	*Meath.*	Kells, Headfort	3·31	123
Perth	Loch Dhu	5·00	111	*W.M*	Moate, Coolatore	3·27	...
,,	Crieff, Strathearn Hyd.	3·29	132	,,	Mullingar, Belvedere	3·23	132
,,	Blair Castle Gardens	2·80	138	*Long*	Castle Forbes Gdns	3·56	138
Angus.	Kettins School	3·82	142	*Gal*	Galway, Grammar Sch.	5·08	205
,,	Pearsie House	4·14	...	,,	Ballynahinch Castle	5·66	157
,,	Montrose, Sunnyside	2·79	137	,,	Ahascragh, Clonbrock	4·29	154
Aber	Balmoral Castle Gdns.	2·44	105	*Rosc*	Strokestown, C'node	4·07	170
,,	Logie Coldstone Sch	2·64	106	*Mayo.*	Blacksod Point	4·93	175
,,	Aberdeen Observatory	2·59	111	,,	Mallaranny	5·94	...
,,	New Deer School House	3·18	146	,,	Westport House	3·32	117
Moray	Gordon Castle	3·14	148	,,	Delphi Lodge	8·63	143
,,	Grantown-on-Spey	3·63	156	*Sligo*	Markree Castle	3·88	139
Nairn.	Nairn	2·15	119	*Cavan.*	Crossdoney, Kevit Cas.	3·83	...
Inv's	Ben Alder Lodge	3·02	...	*Ferm*	Crom Castle	4·11	148
,,	Kingussie, The Birches.	2·22	...	*Arm*	Armagh Obsy	3·87	163
,,	Loch Ness, Foyers	2·78	114	*Down.*	Fofanny Reservoir	5·61	...
,,	Inverness, Culduthel R.	2·08	112	,,	Seaforde	2·32	88
,,	Loch Quoich, Loan	5·37	...	,,	Donaghadee, C. G. Stn.	2·31	102
,,	Glenquoich	5·06	93	*Antr*	Belfast, Queen's Univ	2·04	88
,,	Arisaig House	4·40	128	,,	Aldergrove Aerodrome	2·96	130
,,	Glenleven, Corrour	...	...	,,	Ballymena, Harryville	4·54	159
,,	Fort William, Glasdrum	4·64	...	*Lon*	Garvagh, Moneydig	2·85	...
,,	Skye, Dunvegan	5·19	...	,,	Londonderry, Creggan.	2·83	108
,,	Barra, Skallary	2·17	...	*Tyr*	Omagh, Edenfel	3·71	143
R&C.	Tain, Ardlarach	2·59	115	*Don*	Malin Head	2·38	97
,,	Ullapool	2·70	106	,,	Dunkineely	3·44	...

Climatological Table for the British Empire, December, 1937

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean.							
	Mean of Day M.S.L. mb.	Diff. from Normal. mb.	Max. °F.	Min. °F.	Max. °F.	Min. °F.	$\frac{1}{2}$ Max. and Min. °F.	Diff. from Normal. °F.	Wet Bulb. °F.	%	0–10	Am'nt. in.	Diff. from Normal. in.	Days.	Hours per day.	Percentage of possible.
London, Kew Obsy.	1011·7	− 2·0	53	26	42·6	34·7	38·7	− 2·7	37·5	89	8·7	3·44	+ 1·15	17	0·8	10
Gibraltar	1018·5	− 1·8	68	42	58·8	49·4	54·1	− 1·9	48·8	77	5·5	7·83	...	12	...	...
Malta	1014·4	− 1·8	70	43	60·3	51·3	55·8	− 2·1	50·4	73	7·2	4·77	+ 1·06	17	4·5	46
St. Helena	1011·9	− 1·4	67	56	63·8	57·4	60·6	− 0·3	58·5	95	10·0	2·09	+ 0·76	25	...	...
Freetown, Sierra Leone	1009·8	+ 0·6	89	69	86·6	75·0	80·8	...	76·6	81	4·7	2·14	+ 0·72	3	...	...
Lagos, Nigeria	1009·9	− 0·1	92	68	88·4	73·8	81·1	− 0·7	75·5	89	5·3	1·26	+ 0·45	5	6·9	59
Kaduna, Nigeria	1011·9	...	95	54	91·4	57·8	74·6	+ 1·3	56·3	53	2·6	0·00	0·00	0	9·4	82
Zomba, Nyasaland	1008·9	+ 0·4	91	60	81·0	66·1	73·5	+ 0·4	70·7	81	6·5	8·99	− 1·88	15	...	...
Salisbury, Rhodesia	1010·1	− 0·4	87	54	78·8	59·8	69·3	− 0·3	61·9	67	7·8	8·79	...	16	5·9	45
Cape Town	1014·2	− 0·1	92	54	79·7	60·5	70·1	+ 2·2	60·9	63	3·0	0·02	− 0·79	1	...	...
Johannesburg	1011·1	− 0·1	85	45	72·2	54·4	63·3	− 2·2	57·3	76	5·7	8·45	+ 3·02	24	6·7	49
Mauritius	1013·6	− 0·1	94	66	85·8	70·7	78·3	0·0	73·0	66	5·5	1·60	− 3·08	15	8·8	66
Calcutta, Alipore Obsy.	1014·0	− 1·7	83	50	77·1	56·8	66·9	+ 0·4	56·7	76	2·1	0·09	− 0·15	0*	...	...
Bombay	1012·0	− 1·5	90	64	84·1	68·0	76·1	− 1·3	65·3	68	3·1	0·00	− 0·05	0*	...	...
Madras	1012·6	− 0·9	84	59	81·2	67·2	74·2	− 2·5	69·0	80	4·7	7·25	+ 1·90	5*	...	...
Colombo, Ceylon	1010·9	+ 0·6	88	63	85·0	70·6	77·8	− 1·7	73·1	73	3·6	2·63	− 2·49	5	8·6	74
Singapore	1009·3	− 0·4	89	71	85·3	74·2	79·7	− 0·2	76·0	83	8·2	10·31	− 0·25	24	3·9	33
Hongkong	1017·5	− 2·2	77	53	70·0	61·1	65·5	+ 2·5	59·6	70	6·8	0·61	− 0·42	4	5·4	50
Sandakan	1008·6	...	89	71	85·2	74·9	80·1	− 0·1	76·8	87	8·9	22·90	+ 4·26	22	...	...
Sydney, N.S.W.	1009·6	− 2·3	96	58	78·2	65·8	72·0	+ 1·9	66·0	66	7·1	2·49	− 0·37	14	7·7	53
Melbourne	1010·1	− 2·6	96	46	76·4	55·6	66·0	+ 1·2	58·9	60	7·7	1·42	− 0·85	15	6·4	43
Adelaide	1010·8	− 2·5	103	52	79·6	59·7	69·7	− 1·4	60·5	52	5·4	2·22	+ 1·19	6	8·0	56
Perth, W. Australia	1012·7	− 0·5	93	52	79·1	60·0	69·5	− 1·3	59·5	46	3·8	0·17	− 0·39	5	11·4	80
Coolgardie	1009·8	− 1·4	106	51	88·0	60·0	74·0	− 1·7	61·4	49	2·7	0·11	− 0·58	1	...	...
Brisbane	1010·5	− 1·5	94	63	84·8	68·0	76·4	0·0	69·9	65	6·0	4·53	− 0·36	14	9·3	67
Hobart, Tasmania	1009·7	0·0	83	43	67·3	52·0	59·7	− 0·5	53·4	61	8·3	2·56	+ 0·57	18	5·7	37
Wellington, N.Z.	1014·0	+ 1·8	76	49	68·4	55·0	61·7	+ 1·5	59·0	76	7·2	3·18	− 0·04	12	7·3	48
Suva, Fiji	1009·7	+ 1·1	89	71	84·8	74·0	79·4	+ 0·4	74·5	78	6·9	5·51	− 7·01	20	5·9	45
Apia, Samoa	1008·1	− 0·2	88		85·5	74·5	80·0	+ 0·7	75·9	76	6·1	11 17	− 2·72	21	6·2	48
Kingston, Jamaica	1012·7	− 1·3	89	3	85·7	69·7	77·7	0·0	68·0	86	5·4	0·58	− 1·01	5	...	...
Grenada, W.I.	1010·3	− 1·5	88	1	86	73	79·5	+ 1·3	73	74	6	10·85	+ 3·65	22	..	...
Toronto	1019·2	+ 1·6	43	2	33·0	21·9	27·5	+ 0·4	...	...	6·8	0·76	− 1·71	4	2·4	27
Winnipeg	1020·5	+ 1·8	38	−25	14·5	−3·4	5·5	− 0·3	...	...	5·7	0·00	− 0·94	0	2·1	26
St. John, N.B.	1016·7	+ 2·7	49	−5	30·8	17·6	24·2	− 0·2	20·7	80	6·2	1·91	− 2·26	7	3·3	37
Victoria, B.C.	1016·1	− 0·6	52	27	46·3	38·6	42·5	+ 1·4	40·9	90	8·4	6·94	+ 1·20	22	2·0	24

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Climatological Table for the British Empire, Year 1937

STATIONS.	PRESSURE.		TEMPERATURE.								Relative Humidity.	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.					Mean.							
	Mean of Day M.S.L.	Diff. from Normal.	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.		Wet Bulb.			Am'nt.	Diff. from Normal.	Days.	Hours per day.	Percentage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.		°F.	%	0–10	in.	in.			
London, Kew Obsy....	1012·8	− 2·6	85	25	57·3	44·8	51·0	+ 0·8		46·1	87	7·7	29·67	+ 5·87	164	3·7	28
Gibraltar................	1017·1	− 0·8	92	42	67·2	57·9	62·5	− 1·7		57·3	83	5·1	34·54	...	92	...	...
Malta......................	1015·3	0·0	95	43	71·2	61·3	66·2	+ 0·1		61·0	75	4·5	16·69	− 3·17	65	8·2	66
†St. Helena..............	1013·5	− 1·0	75	52	65·0	58·3	61·6	+ 0·9		59·2	94	9·5	35·51	+ 5·49	212	...	...
Freetown, Sierra Leone	1011·5	+ 1·7	93	68	85·7	74·2	80·0	...		75·6	81	5·8	149·87	− 7·36	175	...	...
Lagos, Nigeria	1011·5	+ 0·6	94	68	86·3	75·5	80·9	+ 0·2		75·7	87	7·2	81·81	+ 9·83	121	6·1	50
Kaduna, Nigeria	1011·6	...	101	50	89·4	65·3	77·4	+ 0·9		65·4	69	5·4	44·93	− 8·90	98	7·8	65
Zomba, Nyasaland	1012·0	− 0·3	95	46	78·9	60·7	69·8	+ 0·4		65·9	78	5·3	48·43	− 6·11	92	...	...
Salisbury, Rhodesia...	1014·1	− 0·5	95	36	77·5	53·5	65·5	+ 0·2		56·5	57	3·7	28·17	...	81	8·0	67
Cape Town	1017·3	+ 0·3	98	38	72·1	54·8	63·4	+ 1·1		56·0	78	4·4	28·04	+ 3·00	110	...	...
Johannesburg	1015·3	+ 0·1	90	23	71·0	49·9	60·5	+ 0·7		50·5	56	3·0	32·27	− 0·95	98	8·6	72
Mauritius	1015·4	− 0·7	94	53	80·6	67·9	74·3	+ 0·3		70·7	75	5·6	54·78	+ 5·03	213	7·9	65
Calcutta, Alipore Obsy.	1007·1	− 0·5	106	49	87·4	71·3	79·3	+ 0·7		71·9	84	5·2	75·41	+ 11·09	83*	...	...
Bombay	1008·5	− 0·7	94	61	86·3	73·9	80·1	− 0·5		72·9	78	4·5	70·72	− 1·47	84*	...	...
Madras	1008·1	− 0·7	106	59	90·0	75·4	82·7	− 0·4		75·0	75	6·3	61·38	+ 11·82	63*	...	...
Colombo, Ceylon	1009·8	+ 0·1	90	63	85·8	75·3	80·6	− 0·5		76·6	77	6·4	103·81	+ 23·68	184	7·2	60
Singapore	1009·3	− 0·2	93	70	86·1	76·1	81·1	+ 0·2		77·3	80	7·1	89·19	− 5·93	192	5·8	48
Hongkong...............	1011·8	− 0·7	93	46	78·1	69·7	73·9	+ 1·7		69·0	78	7·2	82·51	− 3·22	144	5·2	43
Sandakan	1009·0	...	92	71	88·1	75·5	81·8	+ 0·5		77·3	84	7·8	122·14	− 2·65	191	...	...
Sydney, N.S.W..........	1016·2	+ 0·3	98	41	70·9	57·0	63·9	+ 0·8		58·0	68	6·2	52·00	+ 4·52	157	6·5	54
Melbourne	1016·7	+ 0·4	99	30	68·1	49·7	58·9	+ 0·5		52·7	69	6·6	21·45	− 4·02	144	5·4	44
Adelaide	1017·5	+ 0·4	106	38	72·7	53·9	63·3	+ 0·3		55·5	59	6·2	23·01	+ 1·86	128	6·3	52
Perth, W. Australia ...	1017·1	+ 0·7	108	36	74·0	55·8	64·9	+ 0·7		57·0	61	4·7	35·28	+ 0·91	118	8·3	68
Coolgardie	1016·0	+ 0·1	110	30	76·6	52·1	64·4	− 0·2		55·3	60	3·4	11·18	+ 0·91	46	...	...
Brisbane..................	1016·0	+ 0·1	101	42	77·8	60·2	69·0	+ 0·1		62·2	65	4·6	34·79	− 10·50	113	7·7	63
Hobart, Tasmania......	1014·9	+ 2·4	98	30	61·5	47·1	54·3	− 0·1		48·6	66	6·2	20·65	− 3·14	160	5·7	47
Wellington, N.Z.	1015·3	+ 0·7	76	33	59·5	47·7	53·6	− 1·7		50·8	77	7·1	34·15	− 13·89	159	5·7	46
Suva, Fiji	1011·6	+ 0·3	94	63	83·3	73·1	78·2	+ 1·2		73·6	82	6·8	106·63	− 10·51	260	5·2	43
Apia, Samoa	1010·0	− 0·3	90	69	85·2	74·4	79·8	+ 1·3		76·1	77	5·5	110·87	+ 1·16	203	7·0	58
Kingston, Jamaica	1012·9	− 0·8	94	63	87·1	71·8	79·4	+ 0·1		70·3	82	3·6	28·10	− 5·49	79	...	...
Grenada, W.I.	1011·1	− 1·2	90	70	86	73	79·5	+ 0·6		73	74	...	76·49	+ 1·90	234	...	...
Toronto..................	1016·3	− 0·3	95	2	54·9	40·3	47·6	+ 2·4		...	...	6·0	31·92	+ 0·63	131	5·4	42
Winnipeg	1016·4	+ 0·2	97	−37	45·2	25·5	35·4	+ 0·8		...	...	5·5	18·05	− 2·13	115	5·4	42
St. John, N.B.	1015·1	+ 0·5	87	− 5	51·5	36·1	43·8	+ 2·7		39·5	79	6·6	39·57	− 8·51	159	5·4	43
Victoria, B.C............	1015·9	− 0·7	88	19	55·4	43·7	49·6	+ 0·2		46·3	83	6·8	30·43	+ 0·12	161	5·4	42

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

For corrections to 1937 tables see *Errata* p. 129

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traffic between Nairobi and Mombasa on the 25th and rendering the Mombasa aerodrome unusable. Fourteen inches of rain were recorded in 3 days in Mombasa. (*The Times*, May 7th–27th.)

The most widespread drought since 1902 in New South Wales was broken when heavy rains began to fall on the 24th. Anxiety for crops has been relieved as the rain has been accompanied by unusually mild weather. (*The Times*, May 25th–28th.)

The steamer *Mandalay* was sunk after a collision in heavy fog in lower New York Bay on the 29th. (*The Times*, May 30th.)

Daily Readings at Kew Observatory, May, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain.	Sun.	REMARKS
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1014·4	NNE.5	45	52	65	0·01	0·6	pr$_0$ 1h., 12h. and 14h.
2	13·9	E.4	43	53	69	Trace	0·2	id$_0$ 6h.–10h., r$_0$ 17h.
3	15·8	NE.4	45	49	77	0·28	0·0	r$_0$–r 7h.–15h., r$_0$ 23h.
4	17·7	ENE.5	48	57	53	—	5·1	
5	18·7	ENE.4	43	60	39	—	13·6	
6	18·8	NE.3	43	60	52	—	9·7	
7	18·3	NNE.4	40	53	51	—	3·3	x early.
8	23·2	WNW.1	31	55	44	—	10·4	x early.
9	17·4	SW.3	34	58	41	—	3·3	x early.
10	20·7	WNW.1	39	61	50	—	4·3	x early.
11	24·8	S.3	45	65	40	—	12·1	
12	20·1	SSW.4	40	67	43	0·01	10·8	ir$_0$ 19h.–22h.
13	17·5	SSW.4	52	65	63	Trace	1·4	pr$_0$ 10h.
14	07·7	SE.2	50	75	47	0·02	3·6	ir$_0$ 15h. and 18h.–23h.
15	09·6	S.4	55	67	58	0·02	8·2	r$_0$–r 2h.–3h.
16	14·0	S.4	52	62	76	Trace	1·3	pr$_0$ 8h. and 9h.
17	12·0	SE.2	47	60	80	0·09	0·0	ir$_0$ 11h.–15h., r 18h.
18	07·5	NW.3	46	58	56	0·03	1·0	r$_0$–r 19h.–23h.
19	16·1	NW.3	42	55	50	—	3·7	
20	19·1	NE.3	40	57	57	Trace	9·6	pr$_0$ 12h.
21	24·5	NNE.4	40	61	44	—	14·1	x early.
22	25·1	NNW.3	41	69	55	—	10·4	
23	16·5	SW.4	46	70	54	—	6·4	w early.
24	16·1	NW.4	45	61	50	0·02	5·9	pr 9h. and 13h.
25	13·4	SW.2	49	57	78	0·13	0·4	ir$_0$–r 8h.–16h.
26	09·0	S.4	43	62	59	—	3·9	fe till 8h.
27	00·5	SSW.2	51	65	74	Trace	1·3	pr$_0$ 11h., 12h. and 13h.
28	01·7	WNW.3	51	55	87	0·48	0·8	r$_0$–r 7h.–13h., 17h.–22h.
29	07·3	SSW.4	45	60	59	0·07	6·4	ir$_0$–r 16h.–21h.
30	01·7	W.4	48	61	64	0·05	8·2	pr$_0$ 7h.–13h., t 14h.
31	1010·8	S.5	45	59	77	0·09	1·4	d$_0$ 13h., r$_0$ 19h.–22h.
*	1014·6	—	45	60	58	1·30	5·2	*Means or totals.

General Rainfall for May, 1938

England and Wales	124
Scotland	136
Ireland	139
British Isles ...	130

per cent of the average 1881–1915.

(42477) Wt. 21/31 1,125 6 38 Hw. G.377/6

Frontispiece.

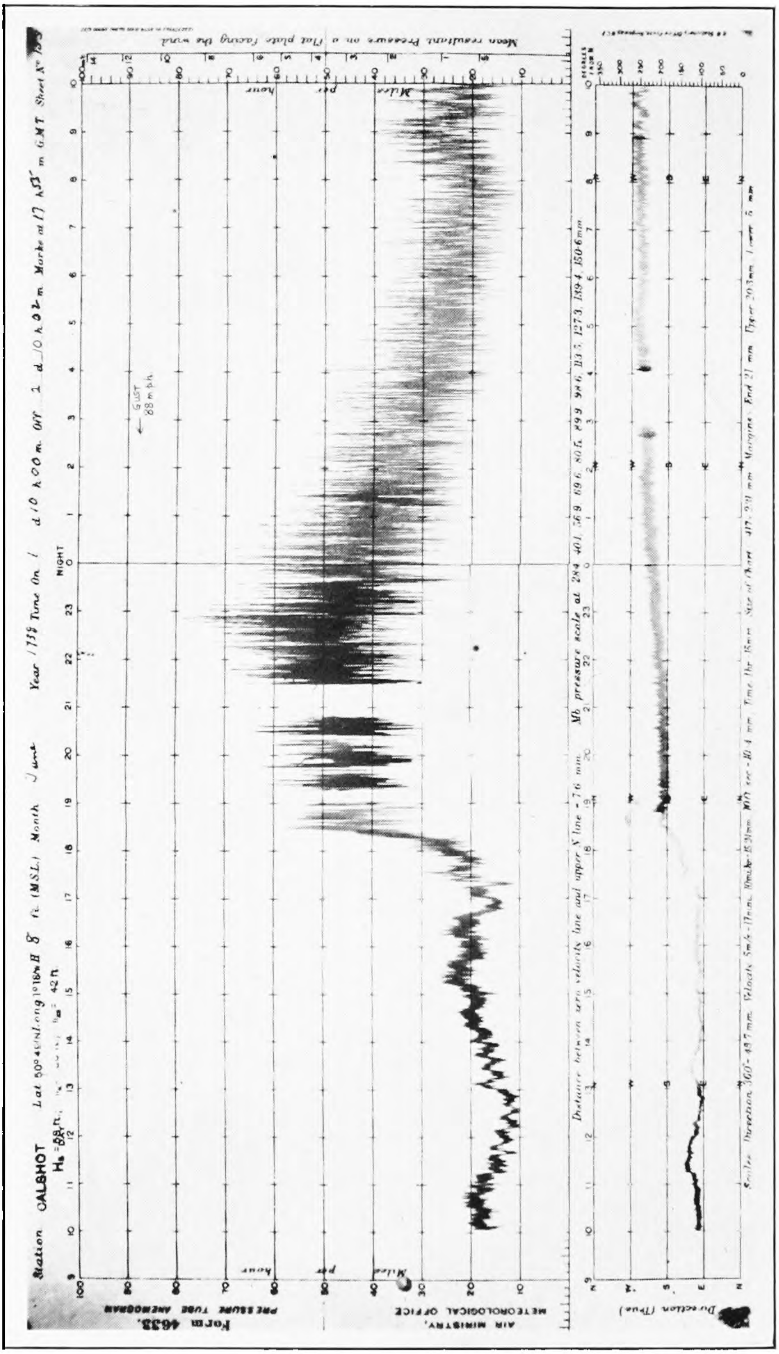

FIG. 1.—CALSHOT ANEMOGRAM, JUNE 1ST–2ND, 1938.

M.O. 422.

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ATMOSPHERIC SODIUM

By Professor S. Chapman, F.R.S.

To anyone who has seen sodium hissing and spitting on the surface of water, with a hydrogen flame playing around it (the hydrogen being evolved in the combination of the sodium with the water), it must come with rather a shock to learn that there is free sodium in the atmosphere. It exists there, however, only in the form of an extremely rare vapour, and doubtless it survives long only at levels where water also is rare, causing combination of the sodium atoms with water molecules to be a very infrequent event.

The discovery and proof of the presence of sodium in the atmosphere are due to the skilled efforts of several distinguished pupils of Professor Fabry—MM. Cabannes, Dufay and Déjardin, and their own pupils MM. Gauzit and Bernard. Spectroscopic methods were employed, the well-known D lines of sodium (at wave-length 5893A) having been detected in the spectrum of the light from the sky, at twilight and also, with much longer photographic exposures, during the night. During the few minutes after sunset, when the sky is rapidly darkening, the continuous spectrum of the sunlight scattered by the air fades much faster than does the light emitted by the sodium atoms in the air, so that the spectrum reveals this light by bright lines superposed on a faint background. The sky spectrum also shows the famous green auroral line now known to be due to atomic oxygen, but whereas this line is visible, without great change of intensity, from twilight onwards throughout the night, the sodium yellow lines, which are at least as strong as the oxygen line just about sunset, fade almost completely away during an interval of a few minutes. Delicate measurements of their wave-length, by interferometer methods, confirm the identity of these lines with the double D line of sodium, both at twilight and also during the night.

The rapid fading of the sodium light at sunset is interpreted as indicating that the sodium is stimulated to luminescence by sunlight: at the time when the sodium light has sunk to insignificance compared with the oxygen green light, the lower limit of the sunshine still traversing the highest layers of the atmosphere is about 60 kilometers or 40 miles, and this is taken as indicating that the sodium lies mainly below this level. During the night the emission of sodium light is at an altogether lower intensity, corresponding to a much weaker stimulus; it seems not unlikely that the energy necessary to excite the sodium atoms to emit light is then imparted to them by collisions with other atoms or molecules around them, which already possess excess energy; the emission of the green oxygen light throughout the night implies the presence of metastable oxygen atoms, continually produced during the recombination of atomic oxygen to form oxygen molecules; the sodium light doubtless derives its energy from the same source, that is, the energy of dissociation of oxygen by ultraviolet sunlight during the day.

Sodium is a light element—its atomic weight is 23, as compared with the molecular weights 28 and 32 for nitrogen and oxygen (though atomic oxygen, at 16, is lighter): hence sodium atoms can easily remain at high levels. They will probably tend to combine with molecular oxygen (and with atomic oxygen in triple collisions involving also a third atom or molecule), as well as with water molecules. Such combinations will load the sodium atom with a companion, forming a heavier molecule, which will tend to sink to lower levels; but this process is slow and the sodium compound may also be sundered again into its constituent atoms by sunlight. Hence the life of the sodium at great heights, where these processes go on slowly, is likely to be long.

Speculation is already active concerning the source of the sodium of the high atmosphere. Professor Fabry, in a recent lecture before the Royal Astronomical Society, broached the suggestion that the sodium might come from interstellar space, which is not absolutely empty but contains gas of a very low density, notably of calcium vapour and also a small amount of sodium vapour. The sun with all its family of planets is travelling through space with a speed of about twenty kilometres per second, and the earth must sweep up the sodium and other atoms lying along its track. In the course of the few thousand million years of the earth's existence an appreciable amount of sodium must thus have entered the earth's atmosphere from outside. Even if this amount is as large as that which to-day exists in the atmosphere, we cannot be sure that this atmospheric sodium is of interstellar origin without knowing the rate at which free sodium is removed from the atmosphere by combination and settling down to the ground, or in other ways.

Professor Fabry has also discussed the possibility that the atmospheric sodium is of terrestrial origin; when spray from the oceans evaporates in the air sodium chloride is left behind, and some of this may be in molecular form instead of in larger aggregations. The sodium chloride molecules will be carried up to heights of many kilometres, and possibly up to 60 km. height, by atmospheric turbulence. Above the ozone layer, at least, such molecules would doubtless be dissociated into sodium and chloride ions, which in the presence of the many ions and electrons known to exist at high levels would soon become neutralized by gaining or losing an electron. As yet we are far from having sufficient knowledge to calculate the rate at which this process could supply free sodium atoms to the upper atmosphere. It would also supply free chlorine to the upper air, and though this has not been detected there it would be premature to deny the possibility of its presence.

The sun is yet another possible source of the atmospheric sodium. The Fraunhofer spectrum of sunlight shows by its absorption lines that the outer layers of the sun's atmosphere, which absorb some of the light which passes through them, contain sodium vapour among many other constituents. The occurrence of magnetic storms and auroræ is generally attributed to the emission of streams of gas from the sun, which affect the earth when they impinge upon it. The precise cause and method of emission of such streams are unknown, though Professor E. A. Milne has outlined one process which must result in the emission of sodium and calcium atoms, amongst others, from the sun. It seems quite possible that the sodium in our atmosphere has been supplied and is from time to time replenished by this means. But here again we have too few facts on which to base a satisfactory quantitative estimate of this means of supply. For the present, therefore, the origin of the sodium in our atmosphere must remain in doubt.

The Gales of June, 1938

Over a considerable part of southern England the gale on the night of June 1st–2nd attained a violence unprecedented for the time of year since systematic wind measurements began and possibly for a much longer period. Its full ferocity was felt on the south coast, where considerable damage was done, notably at Bournemouth. The anemogram at Calshot (fig. 1, frontispiece) shows that shortly before 23h. the mean velocity reached 55 m.p.h. The highest gust of 88 m.p.h. occurred about 2h. 40m., when the mean velocity was less. Other notable gusts were 80 m.p.h. at the Lizard, 76 m.p.h. at Pembroke, 68 m.p.h. at Lympne and Scilly, 67 m.p.h. at Croydon.

The gale was the climax of three very disturbed days, at a season when the average gale frequency is at about its minimum. On the night of May 29th–30th gale force was reached at Yarmouth and Spurn Head, and gusts touched 55 m.p.h. at Croydon and 54 m.p.h. at Cranwell. These were outstanding for the season, though eclipsed 48 hours later. Another active depression on the 31st caused a gale at Pembroke and Hartland Point.

The three successive gales accompanied separate depressions moving northeastward on the same frontal system, deepening as they approached our southwest coasts. They were associated with a large difference of temperature between tropical air and polar air from the Greenland–Spitzbergen area. The temperature difference between Mildenhall and Aldergrove on the morning of 1st was at its maximum at 600 mb. pressure (about 13,500 feet), where it amounted to 17°F. The depression of June 1st was first noticeable as a small secondary just north of the Azores at 7h. on May 31st and at 13h. it was more definite, with an observed pressure of 1012 mb. near the centre. There was a wavy front and a chain of depressions extending to Florida, but it is almost certain that the all-important disturbance was a new one. By 7h. on June 1st the depression was centred about 250 miles southwest of Scilly, with a pressure below 998 mb. at the centre. The situation at 18h. is shown by the chart on fig. 2. Pressure was below 988 mb. at the centre, and a gale had developed behind the cold front. A remarkable feature of the chart is the secondary warm sector within the main warm sector. This was largely the result of solar heating over France. The warm front was diffuse and did not extend far eastward, but the cold front was definite. If one only had this chart one would consider the first cold front as the main cold front of the depression but a comparison with previous charts shows that this was not so. The first front formed off the French coast and the second front was the real polar front. Frontogenesis on the continental coasts is common in summer but a warm sector within a warm sector is rare. Both cold fronts can be identified on autographic records in southeast England.

The secondary disturbance which moved up from France gave thunderstorms and heavy rainfall in Kent and Sussex, mostly ahead of the warm front. The main depression also gave heavy rain near the centre (1.93 in. at Scilly) but in between the two belts of heavy rain there was not much rain. The main cold front gave practically no rain in the southeast, indeed after the thunderstorm rains there was no appreciable rain in southeast England till June 10th, when showers caused a temporary break in the dry spell.

The distortion of the isobars caused by the French disturbance greatly increased the suddenness of onset of the gale. This is well shown on the anemogram at Calshot (fig. 1) where the main cold front passed at about 18h. 30m. The instability of polar air often gives an increase of wind behind the cold front, but in this case there was also a great increase of pressure gradient. As with nearly all very severe gales, the peak velocity occurred at a non-frontal trough in the polar air after the depression had assumed something of the structure of a travelling vortex. The wind direction record at Calshot (fig. 1) shows a steady slow veer. The barogram in London also showed the typical smooth rounded structure of the trough. The comparative absence of rain in front of these troughs is due to the fact that there is no convergence when the motion is of the type specified, once the deepening of the depression has ceased, apart

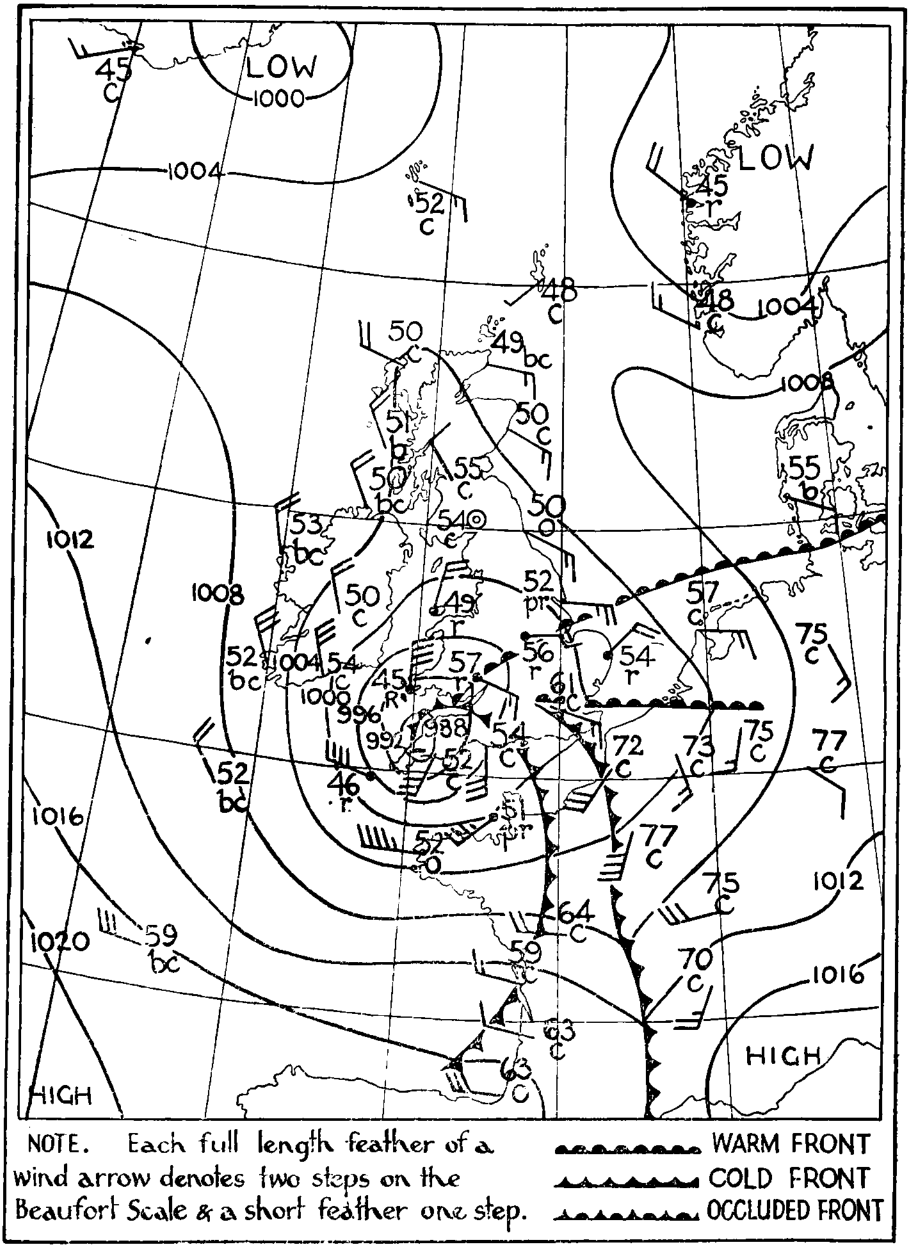

LOW
1000
1004
1008
1012
1016
1020
LOW
HIGH
HIGH
NOTE. Each full length feather of a wind arrow denotes two steps on the Beaufort Scale & a short feather one step.
WARM FRONT
COLD FRONT
OCCLUDED FRONT

Fig. 2.—Synoptic Chart, 18h., June 1st, 1938

from the relatively small frictional influence; there may even be slight divergence ahead of the trough, owing to the curvature effect.

By 1h. on the 2nd the depression was centred just west of Spurn Head and had become slightly less deep. An occlusion extended north from the centre, curving eastward and dividing into warm and cold fronts over the North Sea. At the occlusion there was a departure from the pure vortex structure.

The last three days of June provided two depressions with gales almost as severe as those described above.

On Sunday, June 26th, a complex system travelled over the Atlantic without much development. During Monday, whilst the system crossed Scotland, the pressure at the centre fell from 996 mb. to 968 mb. Widespread gales occurred and gusts of 77 m.p.h. were reported from Aldergrove and 66 m.p.h. from Eskdalemuir.

The next day, Tuesday, June 28th, another complex disturbance, which had formed further west on the same frontal system, crossed the British Isles. The deepening of this disturbance took place throughout its rapid journey across the Atlantic. At 13h. G.M.T. on Monday, about 900 miles west of Valentia the lowest pressure was 1006 mb. At 18h. on Tuesday the lowest pressure over Northern Ireland was about 978 mb. The strongest winds occurred in the south. Gusts of 78 m.p.h. were reported from Manston, 68 m.p.h. from Croydon, and 63 m.p.h. from Pembroke and Lympne. A feature common to all these depressions was the complexity of the frontal structure in the early stages. (The structure of a vigorous disturbance must of necessity be complex later in its life history.) These exceptional disturbances afforded little relief from the dry conditions prevailing in southeast England.

Note on the Effect of Wind on the Temperature of a Thermometer

By E. Gold, F.R.S.

The experimental measurement of wind and of wind pressure has shown that the pressure of the wind on a small circular obstacle is $\frac{1}{2}\rho V^2$ per unit area, where V is speed and ρ is density. This is precisely the pressure to be expected if the obstacle brings to rest the moving air in whose path it lies. But if the obstacle effected this change it would simultaneously turn the kinetic energy of the moving air into heat-energy of the air at rest. In the neighbourhood of the obstacle itself we may suppose that the change will be effectively adiabatic and the temperature of the air brought to rest will be increased by the same amount as the temperature of air in which the pressure is increased adiabatically by an amount $\frac{1}{2}\rho V^2$.

If we write $$\Delta p = \tfrac{1}{2}\rho V^2 \qquad \ldots \qquad (1)$$
then if p is the pressure of the air we have
$$p = k\rho T \qquad \ldots \qquad (2)$$
and for an adiabatic change we also have
$$\frac{\Delta T}{T} = 0{\cdot}284\,\frac{\Delta p}{p} \qquad \ldots \qquad (3)$$
where k is a constant $= 2{\cdot}87 \times 10^6$ in c.g.s. units and T is the temperature on the absolute scale.

We derive from equations (1)–(3)

$$\Delta T = 0{\cdot}142\ V^2/k \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$
$$= 4{\cdot}95 \times 10^{-8}\ V^2 \text{ (V in cm./sec.)}$$

If we transform this to fit the units degrees F and miles per hour we get

$$\Delta T = 1{\cdot}78 \times 10^{-4}\ V^2 \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

The following small table shows the value of ΔT in degrees F. for different values of V in m.p.h.

V =	40	60	80	100	120	140	160	180	200	250	300	350
ΔT =	0·3	0·6	1·1	1·8	2·6	3·5	4·6	5·8	7·1	11·1	16·0	21·8

These values have been derived on the hypothesis that the compression is strictly adiabatic : actually there is certain to be some departure from the adiabatic law, depending among other things on the shape of the thermometer.

Naturally thermometer bulbs are not in ordinary circumstances exposed to winds of the higher speeds of the table : but the thermometers exposed freely on aeroplanes may pass through the air at these higher speeds and have their temperatures affected by several degrees F.—nearly 30° F. for a really fast plane of 400 m.p.h.

The interesting thing which emerges from equations (4) and (5) is that the increase of temperature depends only on the speed and not on the density of the air. Thus the increase will be the same at a height of 10,000 or 20,000 feet as it is at the surface for the same speed. This result surprised me when I saw it and I have therefore thought it might interest other meteorologists also.

Note.—Mr. H. W. Absalom has drawn my attention to a reference to a paper by Polkhausen in Kleinschmidt's " Handbuch de Meteorologischen Instrumente," p. 549, on ΔT's independence of density.

[*Note.*—The reading of a thermometer carried on an aeroplane is modified also by the pressure of the air—not the dynamic pressure of the moving air stopped by the bulb but the static or barometric pressure which decreases with altitude. This pressure effect, though appreciable, is much smaller than the effect of fast moving air. The latter may increase the temperature by several degrees F. The fall of pressure even at heights of 15,000 to 20,000 feet affects the reading of the thermometer by an amount depending on the shape and strength of the bulb but generally less than 0·5°F. The effect is to decrease the reading—the bulb expands slightly as the external pressure on it is reduced and mercury or spirit is taken from the column to fill up the expanded bulb. Thus the effect is on the *reading* of the thermometer—the bulb is not cooled. Even if the aeroplane went to 100,000 feet this pressure effect on the reading would still be small, i.e. between 0·4° and 0·8°F. *See Q.J.R. Met. S.*, 1927, pp. 211 and 438.—Ed. *M.M.*]

OFFICIAL NOTICE

Secretariat of the International Meteorological Organisation

It is announced that Dr. H. G. Cannegieter has resigned his post as Chief of the Secretariat on his appointment as Director of the Meteorological Service of the Netherlands. Dr. Gustav Swoboda has been appointed to succeed Dr. Cannegieter as Chief of the Secretariat.

Royal Meteorological Society

A meeting of the Society was held on Wednesday, the 15th instant, in the Society's rooms, at 49, Cromwell Road, South Kensington. Dr. B. A. Keen, F.R.S., President, was in the Chair.

The following papers were read and discussed.

W. P. Kennedy.—The intensity of ultra-violet radiation from the sky in Iraq.

Hæmatological investigations in Baghdad suggested that the climate altered the blood of normal persons as compared with Britain and, as part of the analysis of the climatic factors, day-to-day measurements were made of the ultra-violet component of northern sky-shine, using Owens's instrument. The daily measurements from August, 1936, to August, 1937, are given in graphic form, and also as monthly means. With the latter, various other meteorological data are tabulated to show the trend and range of climatic variation, and to indicate some of the major causes of fluctuation in the ultra-violet values.

R. C. Sutcliffe, B.Sc., Ph.D.—On development in the field of barometric pressure.

The rate of change of surface pressure is defined by the horizontal divergence of momentum integrated vertically through the entire atmosphere. The approach to the theory of the movement and development of depressions and anticyclones is through a study of the departure of the velocity from the geostrophic value, or, what is the same thing, a study of the field of acceleration. By expanding the acceleration into partial derivatives to time and space, four terms, one of which is the well-known isallobaric term, are obtained. Some justification for considering the terms as physically distinct is given. It is shown that isallobaric effects alone cannot account for the integrated divergence associated with pressure developments and it is suggested that all four terms may be significant. The effect of the vertical space derivative, proportionate to the vertical velocity and to the horizontal gradient of temperature, previously enunciated as a formal proposition (Durst and Sutcliffe, 1938) is stressed as a novel contribution which may be of fundamental importance.

D. Brunt, M.A., B.Sc., and A. K. Kapur, M.Sc.—The amount of water vapour in the stratosphere and upper troposphere.

It is shown that within the stratosphere the humidity mixing ratio should remain constant with height and a simple formula is derived by means of which the total water vapour content of the stratosphere can be derived. This formula indicates that the total is 0·62 times the amount which would be derived on the basis of Dalton's law. The actual amount in the stratosphere above the tropics is found to be very small, equivalent to about 0·01 mm. of precipitable water. The results of computations of the level above which there will be 0·3 mm. of precipitable water (*a*) assuming saturation everywhere in the upper troposphere and (*b*) assuming relative humidity 50 per cent., indicate that in the first case the level of the base of the layer coincides with the isothermal surface of 235° A., and in the second case with the isothermal surface of 245° A. Similar computations are made for 1·2 mm. of precipitable water, assuming 50 per cent. relative humidity in the upper troposphere, and again yield the result that the base of the layer so computed coincides with an isothermal surface.

C. S. Durst, B.A.—The wind structure beneath warm fronts.

Fourteen cases of warm fronts passing over the British Isles were selected and the winds observed by means of pilot balloons were compared with the geostrophic winds, at various heights up to 10,000 feet and at distances varying up to 500 miles. The results were combined in order to get an average value of the departure from the geostrophic wind at certain points. An evaluation is made of the second order terms in the equations at these points and it is concluded that in this region of a depression the departures from the geostrophic wind are primarily dependent on (*a*) the isallobaric term and (*b*) a term involving the velocity of the cold air away from the oncoming warm air and the variation of that velocity in the same direction.

S. Chapman.—The lunar atmospheric tide at Accra, Gold Coast, Africa.

The lunar atmospheric tide has hitherto been determined at two stations on the African continent, Helwan and Kimberley. A new determination has now been made from about three years' bi-hourly data for the tropical African station, Accra (5° 33′ N.; 0° 12′ W.). The annual mean amplitude of the lunar tidal variation of pressure is found to have the rather small value 45 microbars; the phase angle, 72°, implies that the high (lunar) tide in the atmosphere over Accra occurs about half an hour after the moon's transit; this phase lag is quite normal.

The Council of the Royal Meteorological Society has awarded the Howard Prize (an aneroid barometer, given annually for the best essay on a selected meteorological subject) to Cadet Colin Derek Thorpe, of H.M.S. *Conway* School Ship. Consolation prizes have been awarded to Cadet Arthur Vernon Baker (H.M.S. *Conway*), Cadet Godfrey Harry Hayes (H.M.S. *Conway*) and Cadet Richard Christopher Stancliffe Hurst (H.M.S. *Worcester*) who were bracketed second. The subject of the essays was "Clouds."

Correspondence

To the Editor, *Meteorological Magazine*

Sunset Phenomenon at Khartoum

An interesting optical phenomenon was observed in Khartoum on the evening of Sunday, March 13th. The sky was clear except for a few patches of altocumulus cloud at a high elevation and several bands of cirrus extending at an angle of 45° from the horizon near the setting sun to an elevation of about 30° at 1801 Z.T. and patches of colour were noticed on the cirrus cloud with red and green predominating. These patches spread until almost the whole of the cloud above an elevation of 10° displayed colours. In general any patch displayed red above green, but there was no regular rainbow-like configuration. As the sun began to set the colours gradually faded and the cloud went into shadow for a few minutes before developing the usual pink sunset glow. During these last stages it was seen that the cloud was very tenuous and it became almost invisible as the sunset faded. The colours lasted from 1801 to 1808 Z.T. and the sunset pink appeared at 1814 Z.T. According to the "Nautical Almanac" the sun set at 1800 Z.T. at Khartoum on the evening in question.

The phenomenon was of quite a different character from that to which the name iridescence has been given, since the colours were apparent over extended areas of cloud and not merely at the edges (*c.f.* "Observer's Handbook"). Refraction through ice crystals may have been responsible and partial separation of the colours was brought about by certain more favourable planes of orientation although these planes were not sufficiently well defined to give a complete halo-like spectrum.

A. W. IRELAND.

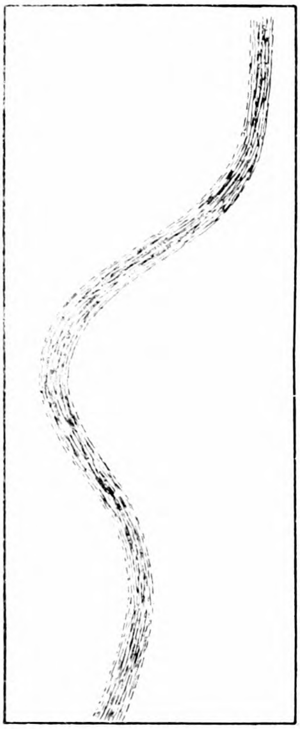
Khartoum, March 17th, 1938.

Sand Devils in the Central Sudan

During the spring of this year some excellent examples of sand devils were observed near Khartoum and near Wad Medani.

One day in March a particularly fine example was observed to form above an area of sand between the White and Blue Nile just across the river from Khartoum. A whirling mass of sand some 50 ft. in diameter appeared first and rapidly developed vertically. The rotation as far as could be ascertained at a distance of approximately 500 yards was anticlockwise. The sand was carried up to a height of about 300 ft. in less than 30 seconds and then growth paused temporarily before a second period of rapid growth during which the upper portion increased in diameter. Within five minutes a sand devil 1,000 ft. in height had developed and there were two apparent breaks in its length in which there did not appear to be any sand. In the lowest 300 ft. sand was very thick and the limits of the whirl well marked, but above 500 ft. the column appeared to be mixing with the surrounding air so that it increased in size laterally and gradually disappeared. Although the active life of this devil, that is its period of development, was only five minutes it persisted in the air stream for at least a further 20 minutes. About the time of development a slow moving cold front was passing Khartoum.

An example of different type was observed at Wad Medani above cotton soil—very fine silt—on May 3rd, 1937. In this case a sand devil developed from a whirl about 6 ft. in diameter. It grew to 10 ft. in diameter at a height of 3 ft. and thereafter exhibited no change in lateral extent up to its upper limit at 150 ft. above the ground. After the initial rapid growth to 150 ft. there did not appear to be any further vertical growth although particles of soil appeared to be carried upwards for at least ten minutes. The density of suspended matter was very great in the lowest 10 ft. where visibility was nil, but above this height the amount of silt in suspension was much less as it was just possible to observe objects on the other side of the whirl. The life of this devil was 15 minutes after which it appeared to " collapse " while the active life was less than one minute. The rotation was anticlockwise.



Sand devil seen to east of Khartoum, April 1937.

On another occasion, in April, 1937, a most imposing sand devil developed to the east of Khartoum, and when first observed appeared like a waterspout, see diagram. The sky was cloudless, and the time noon ; it was estimated that the devil was 3,000 ft. high and 50 ft. in diameter. Owing to the distance of the devil from the observer it was not possible to observe any rotation.

During May 4th and 5th, 1937, 28 sand devils were observed in the Wad Medani district. In 21 cases the rotation was anticlockwise while in the others the devils were too distant for this feature to be decided ; further, all but three were over 200 ft. tall.

William D. Flower.

Meteorological Service, Khartoum, December 19th, 1937.

Lunar Rainbow

Observations of lunar rainbows are rare. During the last ten years I have only been able to find references to five observations in the British Isles, so I am sending an account of the phenomenon I witnessed myself on Whit Monday, June 6th.

Late at night I was cycling from Brynrhydyrarian to Trefnant and at 2236h. G.M.T. I was at a point a few miles W. of Denbigh when a short sharp shower occurred. This soon passed, and just as the rain was ceasing a perfect lunar rainbow became visible, both the primary and secondary bows being complete against a background of mountains and heavy black clouds. It lasted for a minute. The colour was a silvery white, and I was able to discern plainly that the sky below the primary bow and above the secondary was lighter than that between the two bows. All this is the more noteworthy since the moon was only 7⅓ days old at the time and also since a good deal of twilight persisted. The wind was S., force 6–7 on the mountains and less in the valleys, and frequent rainstorms came up and passed quickly. I had previously observed a rainbow in sunlight at 1724h. G.M.T. at Rhydgaled, three miles to the S.

I believe I am correct in stating that Aristotle was the first to report having seen a rainbow in moonlight and also to have stated that they only occur at full moon. About ten years ago I read in a meteorological work that that statement had never been definitely disproved. However, on this occasion, with the transparency of the air and the favourable conditions for rainbow formation which occur in the Welsh mountains during stormy spells, it is quite definite that the moon at first quarter can give enough light to produce a rainbow.

S. E. ASHMORE.

Llannerch Gardens, St. Asaph, Flintshire, N. Wales, June 10th, 1938.

Two Sand Devils

On April 7th, 1938, at 1314h. Sudan Time, while the train in which I was travelling was stationary outside Musmir station, roughly midway between Atbara and Port Sudan in the Sudan, the unusual spectacle of one sand devil moving into the ambit of another was observed. The ground in the region of Musmir is desert, fairly coarse in texture and rather dark in colour, with occasional rocky outcrops and a few scattered bushes. In April the bushes appeared to be dead but no doubt would burst into leaf after the first rainstorm of the " wet " season. For about 500 yards to the south of the railway the ground is unbroken desert while rocky outcrops and bushes occur beyond and the two sand devils to which reference is made developed along the boundary between the two areas. In the initial stages of development it appeared as though two fires of brushwood had been lighted about 300 yards apart. Sand was carried upwards and gave the impression of smoke and this was followed by much denser streaks of sand-laden air which sprang up from the base and played amongst the less dense region much as tongues of flame "lick" upwards from a fire of brushwood. The diameter of the base initially was about 20 feet in each case. The "devils" developed rapidly: the right hand, or westerly, one was the more active and remained almost stationary—its position was fixed relative to a bush—while the other moved slowly towards the west.

At the end of 6 minutes both "devils" were roughly 300 feet tall: the left hand one was 50 feet in diameter at the base and 100 feet in diameter above a height of 50 feet while the one to the right was 100 feet in diameter at the base and 200 feet in diameter above a height of 50 feet. The latter "devil," which was almost black in appearance, was still in process of development as its edges were still "smoking" and "tongues" of heavily sand-laden air continued to shoot out from its upper half. The behaviour of these "tongues" gave the impression that the disturbance was rotating in an anticlockwise sense when viewed from above. The left hand "devil" was less dense and the boundaries fairly sharp: tongues of sand-laden air were no longer in evidence and it was not possible to decide whether there was any rotation.

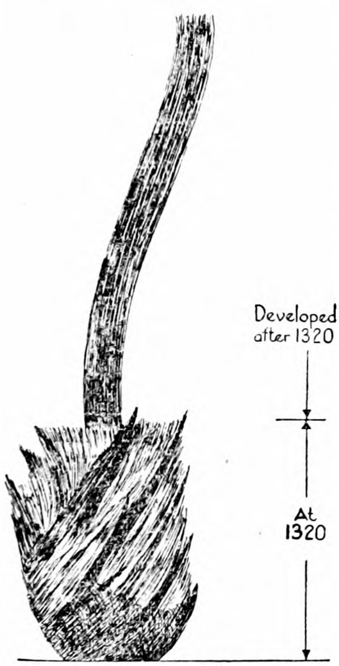


FIG. 1.—SAND DEVIL ON APRIL 7TH, 1938.

At this time the disturbances were 200 feet apart and a dark wave, about 50 feet high and obviously consisting of heavily sand-laden air, was observed to travel rapidly from the smaller to the larger "devil" as though the latter was sucking the substance from the less energetic system. The "devils" appeared joined at their bases for about two minutes after which the left hand one no longer extended right down to the ground but was floating at about a height of 50 feet and it subsequently moved slowly south-eastwards and dispersed. The larger sand devil continued to develop and a sharply defined column, not more than 50 feet in diameter, grew out from the centre of the top. This extended up to at least 1,000 feet and the disturbance was still " active " when the train moved on and hid it from further observation at 1330h.

WILLIAM D. FLOWER.

Meteorological Service, Khartoum, May 2nd, 1938.

NOTES AND QUERIES

Heavy Rainfall at Malta, February 19th—20th, 1938

During February 19th-20th, 1938, Malta experienced a severe storm accompanied by a rainfall which is the heaviest on record for the month of February and the heaviest ever recorded during any month since the Meteorological Office was opened here in 1922.

The synoptic situation was, in many respects, similar to that which gave rise to the gales on November 24th, 1936 (*Meteorological Magazine*, March, 1937) but, as on that occasion, analysis is hampered by the paucity of observations to the south and south-west of Malta

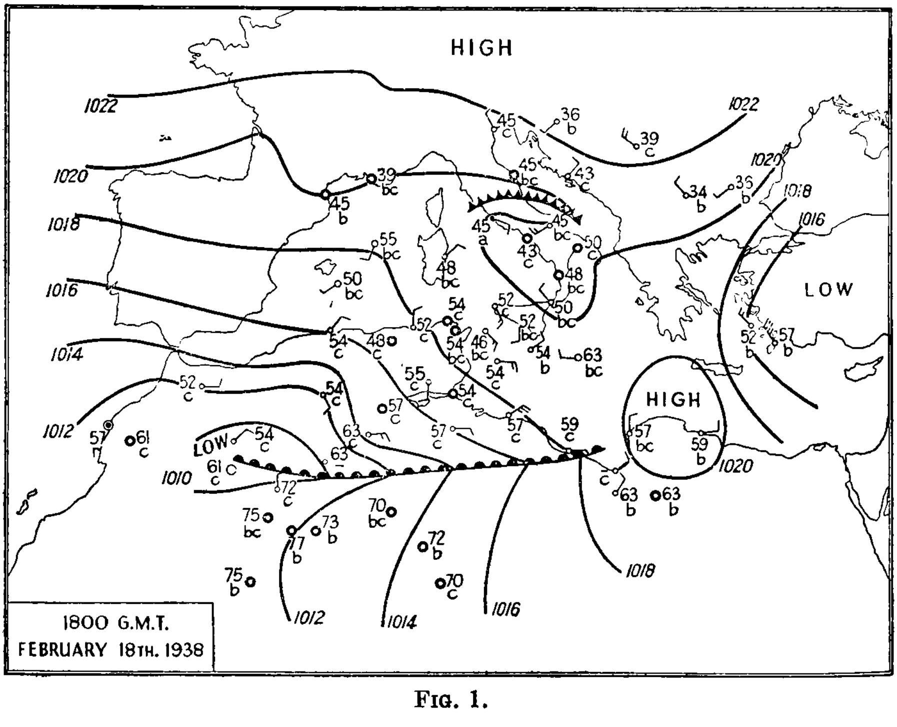

HIGH
1022
1022
1020
1020
1018
1018
1016
1016
1014
1012
1010
LOW
HIGH
LOW
1020
1018
1016
1014
1012
1800 G.M.T.
FEBRUARY 18TH. 1938

FIG. 1.

and the complete absence of information regarding upper air temperatures in those regions. It is hoped, however, that the following notes may be of interest. It should be noted that north-east gales are of particular interest at Malta owing to the harbours being exposed to wind and swell from this direction.

For several days prior to February 19th there had existed a stationary front running east to west across southern Tunisia and Algeria between cool air to the north and warm air, which was relatively moist for that region, to the south. These conditions are shown on the chart for 1800h. G.M.T. February 18th (fig. 1). A nephoscope observation at 1300h. on the 18th gave a velocity of 75 m.p.h. from 280 degrees at the cirrus level. During the night of the 18th–19th a depression developed on this front over the Gulf of Gabes. At 0400h. G.M.T. on the 19th pressure at the centre was 1012 mbs. and light rain had already commenced to fall over a wide area of Algeria and Tunisia. By 0700h. G.M.T. (fig. 2) a

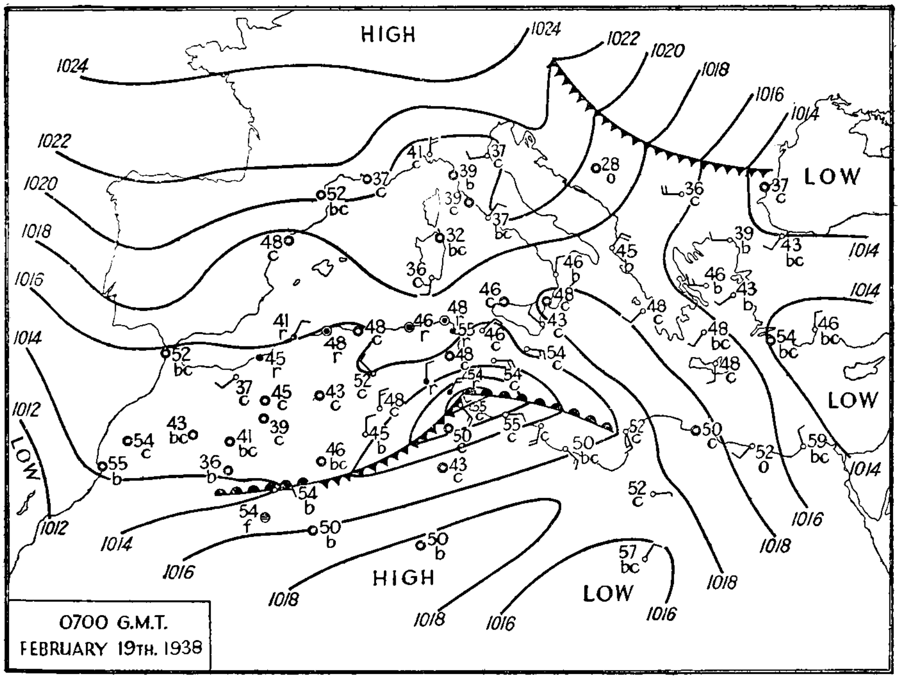


FIG. 2.

further deepening of the centre to 1010 mbs. had occurred and the sky at Malta had clouded over with a sheet of altrostratus. From 0700h. G.M.T. to 1300h. G.M.T. the depression moved rather slowly ENE. while pressure at the centre fell to 1006 mbs. and the wind at Malta backed to ENE. and freshened (*see* fig. 5). (N.B.—The times shown on figs. 5 and 6 are one hour ahead of G.M.T.) By

1300h. G.M.T. the depression had begun to occlude and the cold front was moving eastwards over Libya. Temperatures in the warm sector over Libya exceeded 75°F. at some places during the afternoon.

From 1300h. G.M.T. to 1800h. G.M.T. pressure fell steadily at Malta at a rate of about 1 mb. per hour. Rain began at 1340h. G.M.T. and the wind had steadily increased to force 7 from ENE., by 1800h. G.M.T., with gusts to nearly 60 m.p.h. At 1800h. G.M.T. (fig. 3) the centre was apparently just SSW. of Malta, the lowest pressure reported being 1007 mbs., though it was evident from the strength of the winds that the pressure at the centre must have been considerably lower.

The full violence of the storm occurred at Malta during the night. The 0700h. G.M.T. chart for February 20th (fig. 4) showed that the centre continued to move ENE., passing just south of Malta. The barogram at Malta showed a minimum pressure of about 996 mbs.

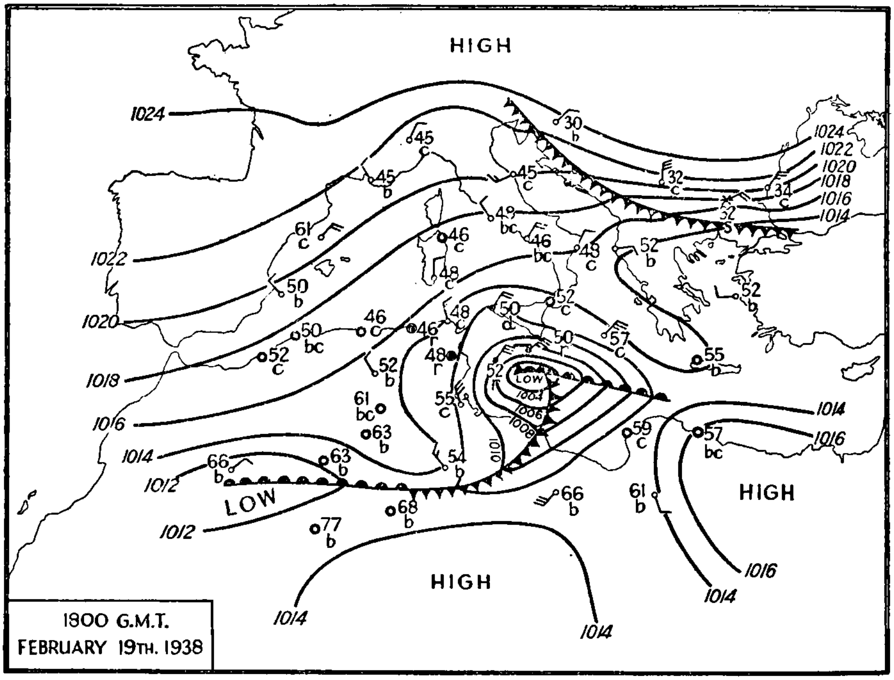


Fig. 3.

between 0030h. and 0300h. G.M.T. on February 20th, more precise measurements being unobtainable owing to the fluctuations of the pen caused by the wind. The anemogram (fig. 5) shows a more or less steady wind velocity of 33 m.p.h. from about 1800h. to 2100h. G.M.T. after which it increased to about 42 m.p.h. with two gusts

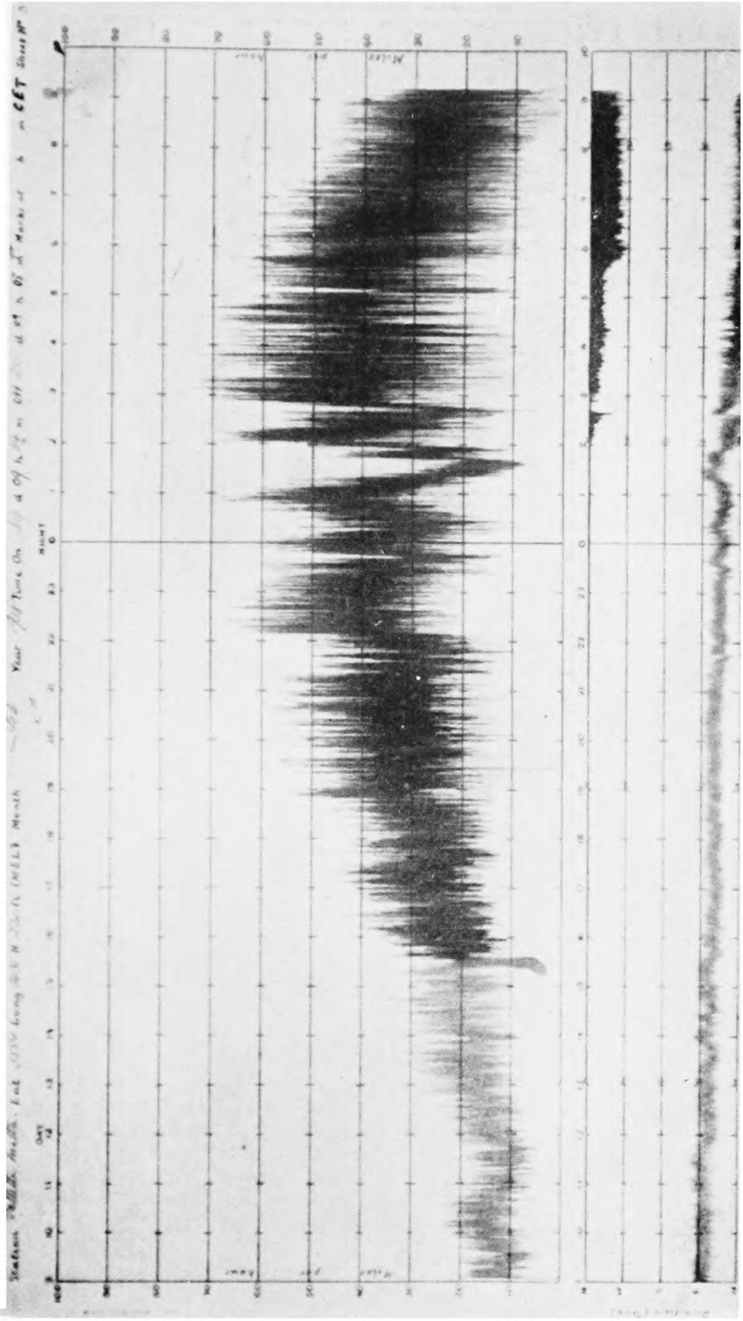


FIG. 5.—MALTA ANEMOGRAM, FEB. 19TH–20TH, 1938.

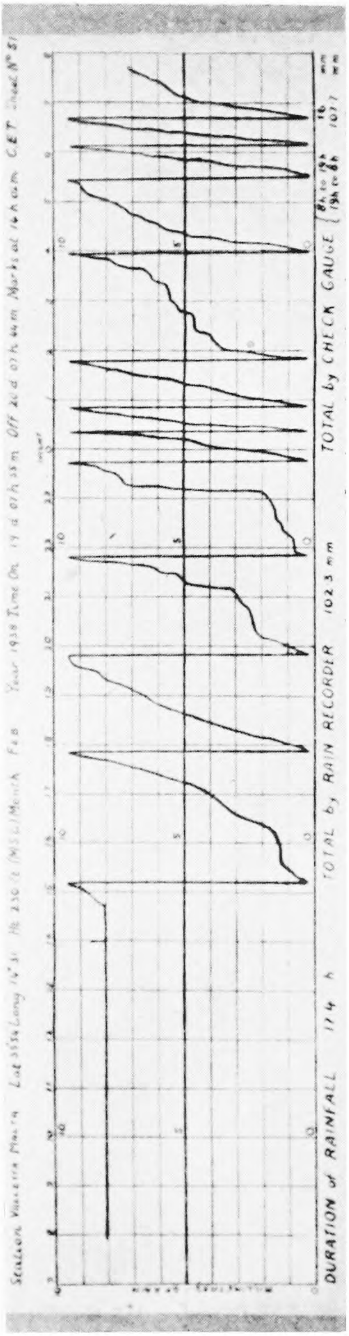


FIG. 6.—MALTA HYETOGRAM, FEB. 19TH–20TH, 1938.

over 70 m.p.h. Minor fluctuations followed until about 0010h. G.M.T. when the velocity commenced to fall rapidly, reaching a minimum value of about 15 m.p.h. at about 0035h. G.M.T. Subsequently the wind increased rapidly again, attaining a mean speed of 50 m.p.h. for a short period about 0110h. G.M.T. and an hour later there was one gust of about 80 m.p.h. During this period the wind direction had been more or less steady from north-east. After 0200h. G.M.T., as the centre moved further away, the velocity fell slowly and the direction backed slowly to north-west.

Apart from the wind the outstanding feature of the storm was the exceptionally heavy rainfall. As may be seen from fig. 6 rain commenced to fall about 1340h. G.M.T. on the 19th and was almost continuous until 0640h. G.M.T. on the 20th. The succeeding rain record shows that the rain continued to fall until 0940h. on the 20th. During the period 0700h. on the 19th to 0700h. on the 20th 123·7 mm. (4·87 in.) of rain were recorded at the Meteorological Office. As may be seen this total actually fell in the period 1340h. on the 19th to 0700h. on the 20th. The normal monthly total of rainfall in February in Malta is 56 mm. (2·21 in.) and the maximum fall for any one day in February hitherto recorded is 79 mm. (3·11 in.) although of course there have been heavier falls in other months. There were two periods when the rainfall was heaviest, viz., 2310h. to 2400h. on the 19th and 0430h. to 0600h. on the 20th. During

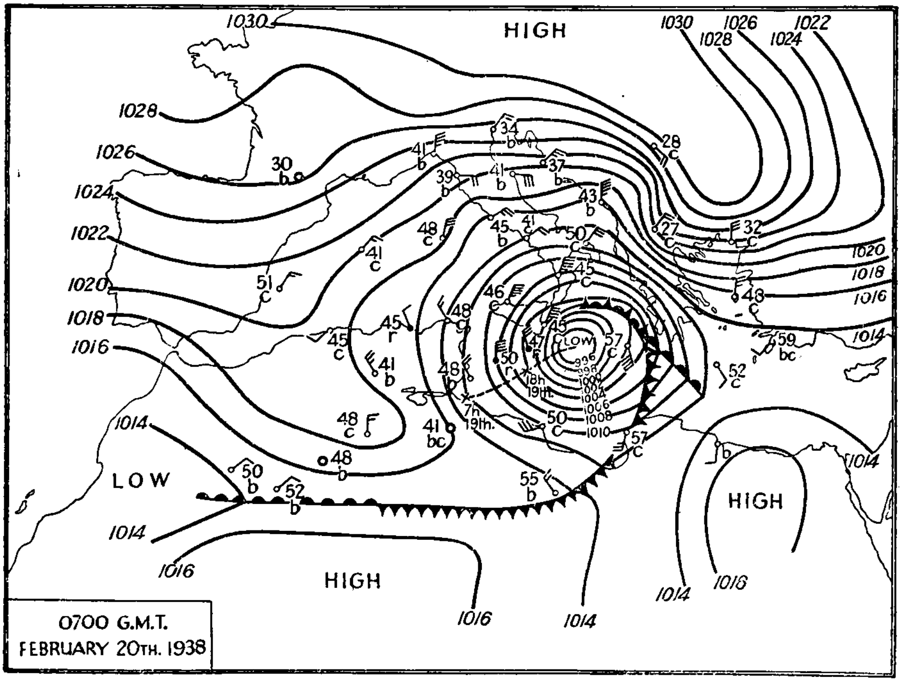

HIGH
1030
1026
1022
1028
1024
1028
1026
1024
1022
1020
1018
1016
1014
LOW
1014
1016
HIGH
1016
1014
1014
1016
HIGH
1020
1018
1016
1014
1014
LOW
996
998
1000
1002
1004
1006
1008
1010
18h
19th
7h
19th
0700 G.M.T.
FEBRUARY 20TH. 1938

FIG. 4.

the first of these periods 17·2 mm. (·68 in.) fell in 50 minutes and the wind increased steadily from 31 m.p.h. to 50 m.p.h. with a gust to 69 m.p.h. During the second period 24 mm. (·94 in.) were recorded in 1½ hours and the mean wind velocity fell steadily from 45 m.p.h., with gusts to 68 m.p.h., to 35 m.p.h. Thunder was reported only once during the night at Malta.

As might be anticipated considerable damage was done locally. A number of walls were blown down and considerable flooding occurred. Quantities of soft soil were washed away into the sea—a point of some importance in Malta where the ground is very rocky and soil scarce. A defence boom across the mouth of Grand Harbour broke adrift and the hospital ship *Maine*, at anchor in one of the creeks, dragged her moorings and swung on to the mud. Finally the P. & O. liner ***Ranpura***, after lying off the entrance to Grand Harbour for some time, continued her voyage eastwards without landing the passengers booked for Malta since the heavy sea and swell rendered the passage through the entrance to the harbour too dangerous.

A. C. Best.
L. Dods.

REVIEWS

The sources of energy of storms. By C. W. B. Normand, C.I.E., M.A., D.Sc. Presidential Address to the Section of Mathematics and Physics, 25th Indian Science Congress, Calcutta, 1938. Calcutta, 1938. Pp. 19.

The object of the paper is to estimate the relative importance of the processes which Margules examined a third of a century ago as possible sources of the energy of storms. The potential energy of the pressure system being found quite inadequate, there are left three sources, (*a*) from vertical decrease of entropy apart from effects due to saturation, (*b*) from horizontal differences of temperature, (*c*) from effects of water vapour: and Normand makes it clear that the last of these plays a very big part in storm formation. He gives a number of easy yet effective methods of determining the energy provided when simplifying assumptions are made; and though these assumptions inevitably lessen materially the value of the numerical results derived, Normand's analysis must add greatly to the amount of insight into the physical processes. There follow applications of these principles to thunderstorms, duststorms and tropical cyclones.

Normand's methods have been found of real practical use in forecasting in India and they must have frequent applications in more temperate climates. This address contains no mathematics beyond easy geometry and is very strongly to be recommended to all who wish for clearer ideas over the fundamental processes of weather. Some of the results of pp. 10–13 are subsequent to Normand's paper recently communicated to the Royal Meteorological Society.

G. T. Walker.

Latent Instability in the Atmosphere revealed by Some Indian Tephigrams. By V. V. Sohoni and M. M. Paranjpe. Poona. Mem. Ind. Met. Dept., 26, Pt. 7, 1937.

It is the practice in the London Meteorological Office to estimate qualitatively, with the aid of the T-ϕ diagram, the latent instability of the air by means of readings of dry and wet bulb temperatures obtained twice daily from aeroplane ascents at Mildenhall and Aldergrove. The criterion of latent instability is that, if a sample of air be raised adiabatically, more energy will be released during the higher portion of its ascent than would have to be supplied in the lower portion. As a frontologist, the meteorologist uses the aeroplane data as an aid to the identification of air masses. As a forecaster, he also uses the data to estimate the possibility of showers or thunderstorms, although he must, of course, allow for a possible change of air-mass. In both cases, the probable effects of radiation, subsidence, turbulence, etc., have to be taken into account.

In the publication under review, the authors summarise their examination of the records of approximately 250 ballon-sonde ascents made at Agra, Poona and Hyderabad. Like the frontologist and the forecaster mentioned above, the authors arrive at certain conclusions regarding latent instability in relation to an air-mass and vice-versa. They find that latent instability is associated with cumuliform cloud, rain and thundery conditions—and generally with incursions of oceanic air of tropical or equatorial origin; similarly, absence of latent instability is associated with dry, fine weather—and mainly with continental air. These findings simply confirm two conclusions already formed by the writer as the result of experience. Firstly, continental air (which tends to predominate in N.W. India during the winter), is more often than not, subsiding air—hence its dryness and relative stability. Secondly, the oceanic air originating from low latitudes (which predominates over most of India during the summer months) is, generally, nearly saturated and potentially unstable; local heating, convergence, or merely the effect of hills or coast lines will produce as a rule sufficient ascent to cause precipitation.

The apparent discrepancies found by the authors may be due, in part, to the fact that trajectories of air based on pilot-balloon ascents separated by an interval of 24 hours cannot be very reliable, especially when it is assumed that no vertical motion has taken place. Moreover, there is little doubt that replacement of continental air by oceanic air is a feature of the western disturbances and possibly of the monsoon depressions also. R. G. VERYARD.

BOOKS RECEIVED

Borough of Darwen : Annual Report of the Medical Officer of Health for the year ending December 31st, 1937. (Section VIII—Meteorology.) Darwen, 1938.

Borough of Worthing : Annual Report on the Health of Worthing, 1937. (Part III—Meteorology.) Worthing, 1938.

OBITUARY

Hugo Hergesell.—Through the death of Geheimrat Hugo Hergesell, which was recorded in our last issue, there has passed away an outstanding figure in the investigation of the upper atmosphere during the past half century. Hergesell was born at Bromberg in 1859 and graduated at the University of Strassburg. In 1891 we find him, still a young man in the early thirties, as the director of the Meteorological Service of Alsace-Lorraine.

Judged by present-day standards it was no doubt a small service, the official functions of which were mainly concerned with the organisation of observations at stations of the second order and the preparation of the usual statistical summaries. But in the Germany of those days the meteorological services of the several states were in close contact with the Universities and as a rule the director also held appointment as professor or lecturer. This double employment had fortunate repercussions. Meteorological work was carried on in academic surroundings and it followed almost as a matter of course that facilities for experimental and other research should be available.

The young Hergesell threw himself with characteristic zeal into the then new field of research of using kites and balloons for extending meteorological observation in the third dimension. He did this to such good purpose that when a proposal to form an international commission to co-ordinate the new work being done in different countries was adopted by the Conference of Directors in Paris in 1896, Hergesell was invited to become its president. He continued to guide the work of the Upper Air Commission up to the outbreak of the War and on the motion of the French members he was asked to resume office at the Leipzig meeting in 1927. He remained President until three years ago when advancing years compelled his resignation. The Commission took advantage of the opportunity for recording its appreciation of the services he had rendered to aerology by nominating him Honorary President.

In 1914 Hergesell left Strassburg to accept the directorship of the Upper Air Observatory at Lindenberg, rendered vacant by the death of Assmann. From the point of view of opportunities for scientific work this was perhaps the most important post that the world had to offer to any meteorologist but pure science was soon to be forced into the background. As Director of Lindenberg it fell to Hergesell's lot to organise the German meteorological service during the War and later on to adapt official meteorology to meet the new needs of aviation. Nevertheless the scientific output from Lindenberg has been fully maintained during the 19 years of Hergesell's directorship.

As president of the Aerology Commission Hergesell was untiring in his efforts to stimulate observation in the free atmosphere in all parts of the world. At a time when facilities for observing were much more limited than they are now he arranged for the concentration of effort on selected "international" days and for the publication of the data for those days in collective form. The financial arrangements for carrying out the latter enterprise by a system of international subscription were made at a meeting of the Commission in St. Petersburg in 1906 and still survive after 30 years which include the Great War.

Of Hergesell's personal work, the researches which he carried out in association with the late Prince of Monaco from the latter's yacht *Princesse Alice* are perhaps the most outstanding. He induced the Prince to extend his interests from oceanography to meteorology and a number of cruises to the trade wind regions and also to the Arctic were arranged. In the course of these Hergesell perfected a method for making ascents with registering balloons at sea. In keen rivalry with Teisserenc de Bort valuable data were collected during the years 1904–6 on which our knowledge of upper air conditions in the trade winds is largely based, while in the Arctic the low altitude of the stratosphere was recorded by observation.

To those of the present generation of meteorologists who had the good fortune to meet him the memory of Hergesell as a genial figure at international meetings will always remain. When in the Chair he was never ruffled even if the discussion became acrimonious. He had the happy knack of putting every one at his ease and converting formal gatherings into pleasant reunions of friends when the day's work was done.

It goes without saying that Hergesell should have been the recipient of many honours and decorations both at home and abroad. He was elected an Honorary Member of the Royal Meteorological Society in 1913 and was awarded the Symons Gold Medal in 1928.

R. G. K. L.

NEWS IN BRIEF

We learn that J. Wadsworth has resigned the directorship of Apia Observatory, Samoa, and expects to leave Samoa shortly.

We learn from *Petermanns Geographische Mitteilungen*, May, 1938, that the Osterreichische Gesellschaft für Meteorologie is in future to be incorporated in the Deutsche Meteorologische Gesellschaft.

We learn that Commandant Fortunato Pires da Rocha has become Director of the Serviço Meteorológico, Ministerio da Marinha, Lisbon, Portugal.

The Weather of June, 1938

Pressure was high (1024 mb.) over the Azores and low over Finland (1004 mb.) and Alaska (1008 mb.). Over most of Europe pressure was almost uniform, about 1018 mb. or 2 mb. above normal but in the British Isles it decreased from 1018 mb. in the south, the normal figure for June, to 1007 mb., 6 mb. below normal, at Lerwick. Thus the gradient for westerly winds was stronger than usual. Areas more than 5 mb. below normal included Iceland, northern Scandinavia and Finland, Arctic Canada and Alaska, but most of North America was slightly above normal. No data were received from the U.S.S.R. Temperature ranged from about 37° F. in the Arctic to above 80° F. in the south-eastern U.S.A. and 90° F. in Egypt. In the British Isles the range was from 50° F. at Lerwick to 61° F. at Kew. Most of Europe was slight above normal but western Ireland, southern Norway, south-west Norrland and north-west Svealand were 1–2° F. below normal. In North America the deviations were mostly small and irregular but the Atlantic coast was warm. Rainfall was above normal in the British Isles (except southern England), Sweden (where the excess was 100–200 per cent. in the western parts of northern Norrland and averaged 60 per cent. over the whole country), Portugal and the Azores, but elsewhere in western Europe it was generally slight. The total of nearly 10 inches (300 per cent. of normal) at Eskdalemuir is notable. Over most of the U.S.A. rainfall was below normal.

In the south-east pressure was above 1020 mb. over south-western Australia, decreasing north-eastwards to 1005 mb. in French Indo-China. The extreme south-west of Australia was 5 mb. above normal, but northern Australia, New Zealand and the East Indies were slightly below normal. Temperature ranged from 45° F. in the south of New Zealand and 47° F. in Tasmania to above 80° F. on the north coast of Australia, Malaya and Indo-China. Northern and central Australia were some degrees above normal, elsewhere the deviations were small. Rainfall was very heavy in Indo-China where totals of 6 to 16 inches were from 2 to 6 inches above normal. Rains were heavy (about 6 inches, or twice the normal) in southern South Australia and on the east coast of South Island, New Zealand, but elsewhere in Australasia they were slight and deficient.

The weather of June over the British Isles was remarkable for the severe gales of the 1st–2nd and 27th–29th*. It was wet in Ireland Scotland, Wales and northern England, but dry in most places elsewhere in England, particularly in the south-east. The excessive rainfall in Scotland was notable; at Eskdalemuir the total was nearly three times the average and at Kirkwall, Orkney, it was the wettest June since records were first taken in 1841. Sunshine was deficient on the whole; there was, however, an appreciable excess locally in south-east England and the Channel Islands.

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* See p. 139.

During the opening days of the month a depression off the mouth of the English Channel moved north-east across England to the North Sea causing severe gales in England on the 1st and 2nd. Thunderstorms were widespread in England on the 1st and occurred locally in northern England on the 2nd, and rainfall was heavy in some parts of Great Britain on the 1st, 3·20 in. at Trecastle, Brecon, and 3·06 in. at Bethesda, Carnarvon, being among the heaviest falls reported. It was very cool on the 2nd, the maximum temperature being only 45° F. at Dalwhinnie and 47° F. at Buxton and Newton Rigg. A secondary depression over west Ireland moved north-east on the 4th and a depression off the west of Ireland moved north-east along the north-west seaboard on the 5th and 6th; rain fell at times in the west and north but little occurred in the south-east. Between the 7th and 9th a depression off the Hebrides moved slowly north and weather was rather unsettled but records of bright sunshine were good on the whole; local thunderstorms were reported in the northern half of the country on the 8th and 9th. Gales occurred locally in the west and north from the 6th–7th. On the 10th a trough of low pressure crossed Great Britain; the day was sunny for the most part but widespread thunderstorms occurred in England. Thereafter the Azores anticyclone moved north-east and a period of mainly anticyclonic weather prevailed from the 13th–17th. High maximum temperatures were registered locally in Scotland on the 13th, in south and east England on the 14th and more generally from the 16th to 18th; 78° F. was registered at Dundee on the 13th, and 79° F. at Bournemouth, Southsea and Southend on the 14th, at Cheltenham on the 17th and at Cleethorpes on the 18th. A trough of low pressure west of Ireland moving over the country caused a renewal of unsettled conditions with local thunderstorms on the 18th, though little or no rain occurred in the south-east. Subsequently pressure was high to the south and south-west of the British Isles, while depressions moved east across the north of Scotland; rain fell at times in the north and west but little was recorded in southern England except on the 22nd. Coastal fog occurred rather frequently on the south-west coasts from the 22nd–27th. Temperature rose to 80° F. at Southend and Camden Square, London, on the 21st and at Walton-on-Naze on the 24th.

A period of very unsettled weather ensued with widespread and severe gales. On the 26th an Atlantic depression approached the west of Ireland and on the 27th it became very intense as it passed north-east across Scotland. On the 28th a new depression moved rapidly north-east across the British Isles. Widespread gales occurred from the 27th–29th and rain fell generally, though the falls were relatively slight in the south-east. Among notable falls in 24 hours were 3·14 in. at Blaenau Festiniog, Merioneth, 2·34 in.

at Rothesay and 2·28 in. at Hawkshead, Lancs, on the 26th and, 3·10 in. at Borrowdale on the 28th.

The distribution of bright sunshine for the month was as follows:—

	Total (hrs.)	Diff. from normal (hrs.)		Total (hrs.)	Diff. from normal (hrs.)
Stornoway ..	101	−66	Chester ..	176	−19
Aberdeen ..	162	−19	Ross-on-Wye	197	−10
Dublin	129	−53	Falmouth ..	229	+ 2
Birr Castle ..	130	−30	Gorleston ..	208	− 1
Valentia ..	184	+11	Kew.. ..	207	+ 4

Kew, Temperature, Mean, 61·3°F, Diff. from average +1·4°F.

Miscellaneous notes on weather abroad from various sources.

A gale off the coast of Brittany on the 1st caused loss of shipping and of several lives. In the middle of the month strong winds and high seas off the Dutch coast delayed dredging operations on the *Lutine.* The river Ume in the north of Sweden was in flood in the early part of the month; it was reported that 100 families were homeless; huge masses of logs were swept downstream by the current, and threatened damage to the port of Umea. In the middle of the month about 48 hours of rain in Switzerland caused several rivers to overflow; The Rhine rose more than 3 feet and navigation was interrupted. Towards the end of the month very hot weather was experienced in much of southern and central Europe; several cases of sunstroke occurred in northern Italy, and six deaths were reported from Budapest where the temperature rose above 98° F. on the 30th. (*The Times*, June 6th–July 1st.)

The S.W. monsoon rains began at Bombay, India about a fortnight earlier than usual, and the rainfall at the city for the first half of June was said to be a record for the last half century; the monsoon was active in most regions. In a duststorm in the western part of Tokachi Province, Hokkaido, Japan, several buildings were destroyed; a layer of dust more than half an inch thick lay on the houses. A very large area in northern Honan, China was flooded by the Yellow river due to the breaching of the dykes and to the high level of the river, which had not however reached its summer peak. In the middle of the month much rain fell in the Yangtze valley region; in Shanghai where the amount for the month exceeded 18 in. streets were flooded for several days. After six days of rain the Yangtze river was much above its normal level; it overflowed south-west of Auking inundating the district near Taihu. At the end of the month there were very heavy rains in the Kwanto district of Japan, during the 24 hours ended at 6 a.m. on the 30th about 11 in. fell at both Tokyo and Yokohama; much damage was done by floods and landslips entailing considerable loss of life. (*The Times*, June 6th–July 1st.)

Heavy rains across the prairie region of Canada on the 8th and 9th gave more than an inch to many districts. On the night of the 10th a tornado struck Clyde, a village in Texas, 13 people were killed, there was considerable damage to property and a goods train was blown off the rails. A hurricane damaged the docks and buildings at the port of Acapulco on the Pacific coast of Mexico on the 27th. (*The Times*, June 11th–29th.)

Daily Readings at Kew Observatory, June, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp. Min.	Temp. Max.	Rel. Hum. 13h.	Rain.	Sun.	REMARKS
	mb.		°F.	°F.	—	in.	hrs.	
1	1005·1	S.3	51	65	71	0·10	1·1	r 15h–16h., r_0 19h.
2	11·1	WSW.5	47	57	56	—	2·6	
3	18·0	WSW.4	45	63	39	—	8·9	
4	13·5	SSW.4	51	70	42	trace	11·8	pr_0 21h.
5	12·3	WSW.3	54	67	39	trace	10·2	pr_0 1h. and 3h.
6	16·4	SSW.4	48	67	57	trace	3·5	d_0 8h.
7	17·1	SSW.4	56	73	65	—	3·4	
8	20·0	SW.3	60	71	75	trace	2·7	pr_0 13h.
9	21·6	W.2	52	67	44	0·01	7·1	ir_0–r 20h.–22h.
10	21·0	W.3	47	64	41	0·02	11·0	pr 9h., 13h. and 14h.
11	23·0	WNW.2	45	64	43	—	9·5	
12	22·1	NW.2	50	64	54	—	2·2	
13	27·1	NNE.4	49	67	46	—	12·6	
14	25·0	WNW.2	55	77	47	—	10·8	
15	25·0	NW.3	52	67	58	—	8·0	
16	27·6	NW.3	51	74	42	—	13·2	
17	23·9	ESE.3	55	76	52	—	6·0	
18	16·1	S.3	52	75	51	trace	4·1	w early, pr_0 17h.
19	17·6	WSW.3	54	73	44	—	8·4	
20	26·1	WSW.2	49	71	40	—	13·0	w early
21	22·0	S.3	50	77	39	—	14·8	
22	20·5	SSW.4	56	75	54	0·01	2·5	ir_0 16h.–18h.
23	20·7	WSW.2	60	75	53	trace	2·0	d_0 7h.
24	17·2	WSW.3	62	75	56	—	7·0	
25	09·7	WSW.4	60	75	53	—	7·9	
26	15·8	SW.4	56	73	50	—	3·6	
27	05·5	SSW.5	62	67	92	0·16	1·1	r_0–r 11h.–14h.
28	06·6	SSW.5	53	68	58	0·02	3·3	ir_0–r 20h.–23h.
29	07·9	W.5	57	66	38	—	7·4	
30	1009·5	SW.4	51	63	55	0·03	7·7	pr_0–pr 17h.–20h.
*	1017·5	—	53	70	52	0·35	6·91	* Means or Totals.

General Rainfall for June, 1938

England and Wales	96	per cent of the average 1881–1915.
Scotland	201	
Ireland	155	
British Isles ...	133	

Rainfall : June, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.
Lond .	Camden Square..........	·34	17
Sur .	Reigate, Wray Pk. Rd..	·65	31
Kent .	Tenterden, Ashenden...	·72	38
,, .	Folkestone, Boro. San.	1·15	...
,, .	Margate, Cliftonville....	1·26	72
,, .	Eden'bdg., Falconhurst	·64	29
Sus .	Compton, Compton Ho.	·77	31
,, .	Patching Farm..........	·69	34
,, .	Eastbourne, Wil. Sq....	1·15	63
Hants.	Ventnor, Roy.Nat.Hos.	·39	21
,, .	Southampton,East Park	·77	38
,, .	Ovington Rectory.......	·90	39
,, .	Sherborne St. John......	·66	31
Herts .	Royston,Therfield Rec.	·61	27
Bucks.	Slough, Upton............	·55	27
Oxf .	Oxford, Radcliffe.........	·95	42
N'hant	Wellingboro, Swanspool	1·60	76
,, .	Oundle	1·62	...
Beds .	Woburn, Exptl. Farm...	1·19	61
Cam .	Cambridge, Bot. Gdns.	·65	31
,, .	March........................	·83	42
Essex .	Chelmsford,County Gdns	·29	15
,, .	Lexden Hill House......	·54	...
Suff .	Haughley House.........	·89	...
,, .	Rendlesham Hall........	·51	27
,, .	Lowestoft Sec. School...	·90	50
,, .	Bury St. Ed., WestleyH.	1·03	49
Norf. .	Wells, Holkham Hall...	2·08	106
Wilts .	Porton, W.D. Exp'l. Stn	·77	40
,, .	Bishops Cannings........	1·85	76
Dor .	Weymouth, Westham.	·41	23
,, .	Beaminster, East St....	1·50	66
,, .	Shaftesbury,Abbey Ho.	1·13	49
Devon.	Plymouth, The Hoe....	1·12	52
,, .	Holne, Church Pk. Cott.	2·80	98
,, .	Teignmouth, Den Gdns.	1·04	54
,, .	Cullompton	1·33	63
,, .	Sidmouth, U.D.C........	1·50	...
,, .	Barnstaple, N. Dev.Ath	1·66	74
,, .	Dartm'r,Cranmere Pool	3·80	...
,, .	Okehampton, Uplands.	2·67	96
Corn .	Redruth, Trewirgie......	1·97	79
,, .	Penzance, Morrab Gdns.	2·11	95
,, .	St. Austell, Trevarna...	2·00	77
Soms .	Chewton Mendip.........	1·91	65
,, .	Long Ashton............	1·29	51
,, .	Street, Millfield..........	1·57	76
Glos .	Blockley	1·20	...
,, .	Cirencester, Gwynfa....	1·68	70
Here .	Ross-on-Wye..............	1·05	48
Salop .	Church Stretton.........	2·56	106
,, .	Shifnal, Hatton Grange	1·45	65
,, .	Cheswardine Hall........	1·97	81
Worc .	Malvern, Free Library...	1·24	53
,, .	Ombersley, Holt Lock.	1·10	49
War .	Alcester, Ragley Hall...	1·04	46
,, .	Birminghm, Edgbaston	2·02	87
Leics .	Thornton Reservoir ...	1·64	76
,, .	Belvoir Castle............	1·50	79
Rut .	Ridlington	1·30	68
Lincs .	Boston, Skirbeck.........	1·00	55
,, .	Cranwell Aerodrome...	1·00	60
,, .	Skegness, Marine Gdns.	·76	42
,, .	Louth, Westgate.........	1·14	53
,, .	Brigg, Wrawby St.......	1·57	...
Notts .	Mansfield, Carr Bank...	1·67	74
Derby.	Derby, The Arboretum	1·42	60
,, .	Buxton, Terrace Slopes	4·27	133
Ches .	Bidston Obsy.............	2·65	120
Lancs.	Manchester, Whit. Pk.	3·60	136
,, .	Stonyhurst College......	4·30	140
,, .	Southport, Bedford Pk.	4·07	188
,, .	Ulverston, Poaka Beck	5·45	169
,, .	Lancaster, Greg Obsy.	4·57	179
,, .	Blackpool	4·06	186
Yorks.	Wath-upon-Dearne......	1·82	82
,, .	Wakefield,Clarence Pk.	1·59	74
,, .	Oughtershaw Hall.......	6·84	...
,, .	Wetherby, Ribston H..	2·25	107
,, .	Hull, Pearson Park......	1·94	94
,, .	Holme-on-Spalding......	2·50	114
,, .	Felixkirk, Mt. St. John.	2·49	114
,, .	York, Museum Gdns....	2·47	119
,, .	Pickering, Houndgate...	2·04	96
,, .	Scarborough..............	2·43	132
,, .	Middlesbrough............	1·87	99
,, .	Baldersdale, Hury Res.	3·40	144
Durh .	Ushaw College............	3·13	145
Nor .	Newcastle, Leazes Pk...	2·83	134
,, .	Bellingham, Highgreen	3·10	135
,, .	Lilburn Tower Gdns....	3·47	168
Cumb.	Carlisle, Scaleby Hall...	4·30	171
,, .	Borrowdale, Seathwaite	13·75	225
,, .	Thirlmere, Dale Head H.	12·64	305
,, .	Keswick, High Hill......	8·52	293
,, .	Ravenglass, The Grove	4·91	188
West .	Appleby, Castle Bank...	2·84	124
Mon .	Abergavenny, Larchf'd	1·99	82
Glam .	Ystalyfera, Wern Ho....	5·95	158
,, .	Treherbert, Tynywaun.	6·84	...
,, .	Cardiff, Penylan..........	2·07	82
Carm .	Carmarthen,M. & P. Sch.	5·21	177
Pemb .	Pembroke,Stackpole Ct.	...	...
Card .	Aberystwyth	3·10	...
Rad .	BirmW.W.Tyrmynydd	5·64	172
Mont .	Newtown, Penarth Weir	..	...
,,	Lake Vyrnwy	6·68	211
Flint .	Sealand Aerodrome......	2·52	124
Mer .	Blaenau Festiniog	12·09	203
,, .	Dolgelley, Bontddu......	7·33	211
Carn .	Llandudno	3·03	150
,, .	Snowdon, L. Llydaw 9..	21·55	...
Ang .	Holyhead, Salt Island...	4·07	189
,, .	Lligwy	5·05	...

Rainfall : June, 1938 : Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem.	5·97	247	*R&C*	Achnashellach	8·44	213
Guern.	St.Peter P't.Grange Rd.	·29	16	,,	Stornoway, C.GuardStn.	4·62	210
Wig	Pt. William, Monreith.	4·14	176	*Suth*	Lairg	3·43	164
,,	New Luce School	4·87	169	,,	Skerray Borgie	4·17	...
Kirk	Dalry, Glendarroch	6·38	229	,,	Melvich	3·61	186
Dumf.	Dumfries, Crichton R.I.	...	...	,,	Loch More, Achfary	7·65	207
,,	Eskdalemuir Obs	9·31	296	*Caith*	Wick	3·51	195
Roxb	Hawick, Wolfelee	3·93	168	*Ork*	Deerness	4·30	234
Peeb	Stobo Castle	4·67	200	*Shet*	Lerwick Observatory	4·13	231
Berw	Marchmont House	4·03	174	*Cork*	Cork, University Coll.	2·78	110
E.Lot	North Berwick Res.	3·05	184	,,	Roches Point, C.G. Stn.	2·93	110
Midl	Edinburgh, Blackfd. H.	2·87	143	,,	Mallow, Longueville	2·53	115
Lan	Auchtyfardle	4·26	...	*Kerry.*	Valentia Observatory	4·20	131
Ayr	Kilmarnock, Kay Park	4·50	...	,,	Gearhameen	8·20	164
,,	Girvan, Pinmore	6·19	214	,,	Bally McElligott Rec.	4·56	...
,,	Glen Afton, Ayr San.	6·49	216	,,	Darrynane Abbey	3·62	115
Renf	Glasgow, Queen's Park	5·81	252	*Wat*	Waterford, Gortmore	3·67	140
,,	Greenock, Prospect H.	7·39	237	*Tip*	Nenagh, Castle Lough.	3.16	129
Bute	Rothesay, Ardencraig	7·65	249	,,	Cashel, Ballinamona	3·45	152
,,	Dougarie Lodge	5·17	190	*Lim*	Foynes, Coolnanes	3·65	141
Arg	Loch Sunart, G'dale	9·49	295	*Clare*	Inagh, Mount Callan	8·31	...
,,	Ardgour House	11·52	...	*Wexf*	Gorey, Courtown Ho.	3·54	146
,,	Glen Etive	...	...	*Wick*	Rathnew, Clonmannon.	2·54	...
,,	Oban	6·76	...	*Carl*	Bagnalstown, Fenagh H.	3·02	122
,,	Poltalloch	6·78	222	,,	Hacketstown Rectory	...	...
,,	Inveraray Castle	11·62	293	*Leix*	Blaudsfort House	3·54	137
,,	Islay, Eallabus	4·50	172	*Offaly.*	Birr Castle	3·44	149
,,	Mull, Benmore	...	...	*Kild*	Straffan House	3·59	158
,,	Tiree	3·52	138	*Dublin*	Dublin, Phoenix Park.	2.58	130
Kinr	Loch Leven Sluice	4.08	186	*Meath.*	Kells, Headfort	4·05	153
Fife	Leuchars Aerodrome	2·50	150	*W.M*	Moate, Coolatore	3·46	...
Perth	Loch Dhu	...	...	,,	Mullingar, Belvedere	4·26	164
,,	Crieff, Strathearn Hyd.	4·53	172	*Long*	Castle Forbes Gdns	4·87	189
,,	Blair Castle Gardens	4·04	204	*Gal*	Galway, Grammar Sch.	4·39	171
Angus.	Kettins School	2·48	119	,,	Ballynahinch Castle	6·77	191
,,	Pearsie House	3·91	...	,,	Ahascragh, Clonbrock.	3·99	143
,,	Montrose, Sunnyside	3·15	190	*Rosc*	Strokestown, C'node	4·20	179
Aber	Balmoral Castle Gdns.	3·29	194	*Mayo.*	Blacksod Point	5·24	188
,,	Logie Coldstone Sch.	3·98	204	,,	Mallaranny	7·21	...
,,	Aberdeen Observatory.	3·33	195	,,	Westport House	3·72	138
,,	New Deer School House	2·59	130	,,	Delphi Lodge	9·89	172
Moray	Gordon Castle	3·11	152	*Sligo*	Markree Castle	5·58	185
,,	Grantown-on-Spey	4·71	209	*Cavan.*	Crossdoney, Kevit Cas.	4·45	...
Nairn.	Nairn	3·03	172	*Ferm*	Crom Castle	4·27	158
Inv's	Ben Alder Lodge	6·33	...	*Arm*	Armagh Obsy	3·55	141
,,	Kingussie, The Birches.	3·86	...	*Down.*	Fofanny Reservoir	7·32	...
,,	Loch Ness, Foyers	4·21	190	,,	Seaforde	3·80	138
,,	Inverness, Culduthel R.	3·44	181	,,	Donaghadee, C. G. Stn.	4·41	189
,,	Loch Quoich, Loan	15·47	...	*Antr*	Belfast, Queen's Univ.	...	...
,,	Glenquoich	13·88	283	,,	Aldergrove Aerodrome.	4·55	189
,,	Arisaig House	8·02	246	,,	Ballymena, Harryville.	5·11	176
,,	Glenleven, Corrour	...	...	*Lon*	Garvagh, Moneydig	3·89	...
,,	Fort William, Glasdrum	8·74	...	,,	Londonderry, Creggan.	5·56	197
,,	Skye, Dunvegan	7·04	...	*Tyr*	Omagh, Edenfel	4·75	168
,,	Barra, Skallary	4·08	...	*Don*	Malin Head	4·95	187
R&C.	Tain, Ardlarach	2·98	146	,,	Dunfanaghy, St. Pat's.	...	...
,,	Ullapool	4·46	189	,,	Dunkineely	5·23	...

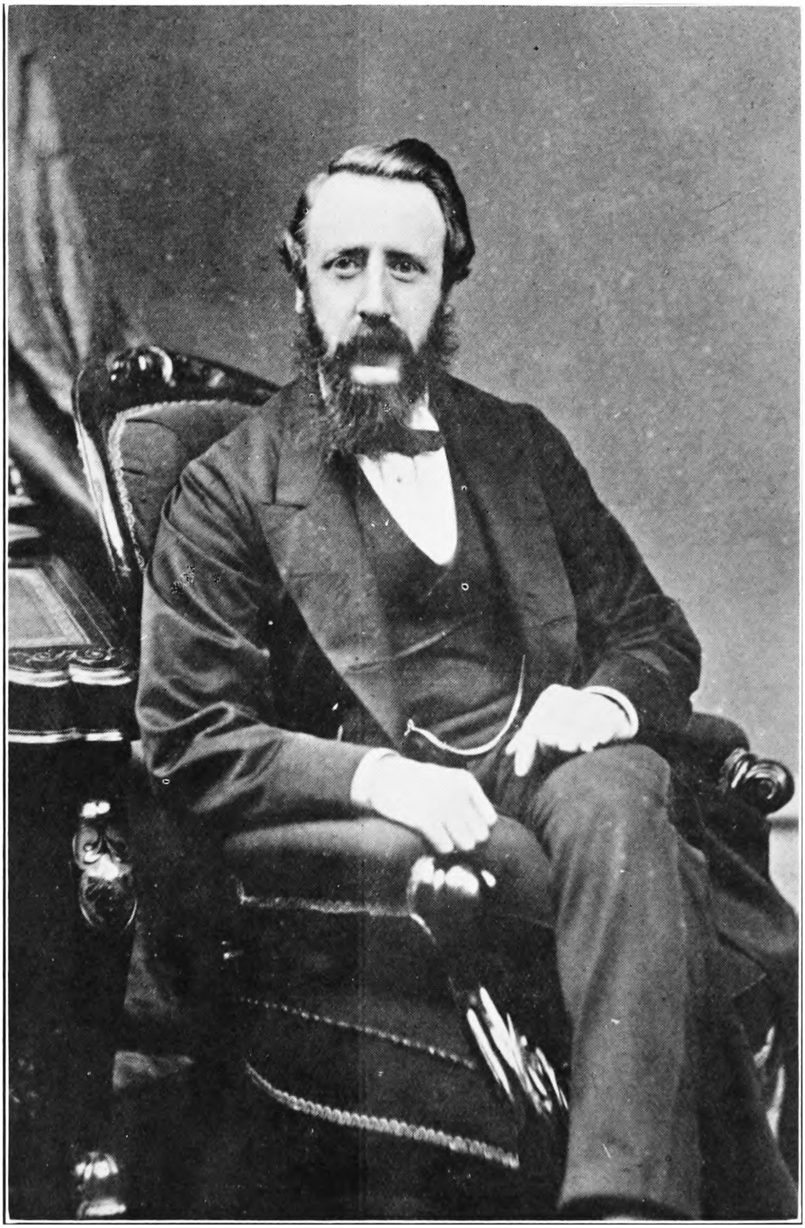
Erratum : Malin Head, May, for 2·38/97 read 2·58/105.

Climatological Table for the British Empire, January, 1938

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal	Wet Bulb			Am'nt.	Diff. from Normal	Days	Hours per day	Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1012·3	− 5·3	55	33	48·4	38·8	43·6	+ 3·1	40·7	87	8·5	2·23	+ 0·47	21	1·4	17
Gibraltar	1023·6	+ 2·1	62	35	57·7	48·1	52·9	− 2·0	48·3	80	4·7	2·17	...	5	...	...
Malta	1015·9	− 1·1	62	42	57·2	49·4	53·3	− 2·0	48·8	78	6·2	5·36	+ 2·15	14	5·2	52
St. Helena	1014·9	− 1·1	70	57	65·8	59·1	62·5	− 0·9	60·2	95	9·9	4·17	+ 2·13	22	...	...
Freetown, Sierra Leone	1009·5	+ 0·4	90	71	86·9	73·6	80·3	...	74·6	81	2·9	0·00	− 0·41	0	...	...
Lagos, Nigeria	1009·5	− 0·1	90	69	87·8	74·3	81·1	+ 0·2	74·9	90	7·4	0·86	− 0·18	4	5·9	50
Kaduna, Nigeria	1012·2	...	98	55	89·8	59·2	74·5	+ 1·1	53·3	41	3·2	0·00	0·00	0	8·6	75
Zomba, Nyasaland	1008·4	+ 0·8	87	61	79·1	66·3	72·7	− 0·1	71·2	87	8·1	23·45	+ 12·35	23	...	...
Salisbury, Rhodesia	1019·2	− 0·6	84	55	77·8	61·0	69·4	− 0·3	63·2	79	8·5	12·15	...	26	5·6	43
Cape Town	1013·1	− 0·3	96	48	79·1	60·9	70·0	+ 0·1	62·0	69	3·8	0·96	+ 0·28	6	...	...
Johannesburg	1009·4	− 0·1	86	52	77·3	57·2	67·3	+ 0·6	59·2	72	5·5	5·15	− 1·02	14	7·2	53
Mauritius	1012·0	+ 0·3	90	68	85·5	73·0	79·3	0·0	74·5	74	5·7	5·25	− 2·91	19	9·2	70
Calcutta, Alipore Obsy.	1015·3	+ 0·1	86	52	81·0	58·8	69·9	+ 3·3	59·9	88	2·3	0·41	− 0·01	2*	...	...
Bombay	1012·9	− 0·7	87	63	82·1	66·6	74·3	− 1·2	64·7	70	0·8	0·00	− 0·10	0*	...	...
Madras	1013·9	− 0·2	86	66	84·2	68·5	76·3	+ 0·1	70·9	88	5·8	0·00	− 1·14	0*	...	...
Colombo, Ceylon	1011·0	+ 0·2	92	69	87·7	72·6	80·1	+ 0·6	74·2	74	4·2	1·74	− 1·51	12	7·7	65
Singapore	1010·7	+ 0·3	89	70	85·2	73·9	79·5	− 0·2	75·7	77	7·9	12·25	+ 2·36	18	4·7	39
Hongkong	1020·7	+ 1·0	77	48	65·7	56·7	61·2	+ 1·0	55·9	74	7·4	0·35	− 0·97	4	4·3	39
Sandakan	1009·9	...	87	72	84·2	75·1	79·7	− 0·1	76·3	87	8·3	22·07	+ 2·67	20	...	...
Sydney, N.S.W.	1012·8	+ 0·4	88	57	78·6	65·9	72·3	+ 0·7	66·3	65	5·9	9·36	+ 5·69	12	8·1	57
Melbourne	1012·9	0·0	103	46	79·1	57·2	68·1	+ 0·7	59·9	55	5·9	1·45	− 0·44	10	7·1	49
Adelaide	1014·2	+ 1·2	104	51	84·4	61·3	72·9	− 0·8	60·6	41	5·2	0·61	− 0·11	7	8·9	63
Perth, W. Australia	1013·7	+ 1·2	103	52	84·1	61·9	73·0	− 0·8	60·3	45	2·8	0·21	− 0·13	2	11·8	97
Coolgardie	1012·7	+ 1·3	103	49	87·4	61·1	74·3	− 3·1	61·3	55	2·1	0·70	+ 0·24	2	...	...
Brisbane	1011·6	+ 0·3	95	66	83·9	70·0	76·9	− 0·3	70·7	70	6·6	7·70	+ 1·25	16	6·7	49
Hobart, Tasmania	1011·2	+ 0·9	89	44	69·6	52·8	61·2	− 0·8	54·2	59	6·5	3·65	+ 1·82	15	7·0	47
Wellington, N.Z.	1016·8	+ 3·5	78	48	70·0	55·8	62·9	+ 0·4	59·4	75	6·9	5·16	+ 1·83	9	8·0	54
Suva, Fiji	1008·1	+ 0·6	89	71	86·8	75·7	81·3	+ 1·4	76·4	83	6·8	12·53	+ 1·10	25	6·2	47
Apia, Samoa	1007·0	− 0·9	90	73	85·9	75·5	80·7	+ 1·7	76·7	79	6·7	20·64	+ 3·59	22	6·8	53
Kingston, Jamaica	1015·2	+ 0·1	88	64	85·5	68·4	76·9	+ 0·1	66·3	82	4·4	0·05	− 0·91	3	5·6	50
Grenada, W.I.	1010·9	− 1·9	88	71	86	73	79·5	+ 2·4	74	78	5	5·84	+ 1·46	17	...	...
Toronto	1016·2	− 1·7	47	− 4	28·7	15·9	22·3	+ 0·1	...	...	8·2	1·63	− 1·16	15	2·1	23
Winnipeg	1020·0	− 0·9	30	−41	8·9	−10·0	−0·5	+ 3·4	...	...	4·4	1·36	+ 0·45	9	3·1	36
St. John, N.B.	1017·4	+ 1·9	48	−12	29·3	13·5	21·4	+ 2·2	16·1	76	5·9	3·95	− 0·85	9	4·4	48
Victoria, B.C.	1019·0	+ 3·0	51	28	44·1	37·5	40·8	+ 1·8	39·6	91	8·3	2·51	− 2·03	19	1·7	19

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

(428 68) Wt. 21/31 1,125 7/38 Hw. G. 377/6.



G. J. Symons at the age of thirty-five
(from a photograph taken at Bradford in 1873)

M.O. 422.

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George James Symons, F.R.S.

Born August 6, 1838; died March 10, 1900.

In this number of the Meteorological Magazine we commemorate the centenary of the birth of the founder of the British Rainfall Organization and of this Magazine. For the article which follows we are indebted to Dr. H. R. Mill, Director of the British Rainfall Organization from 1903 to 1919. The portrait which forms the frontispiece is reproduced from a photograph in the possession of Mr. H. Sowerby Wallis, by whose courtesy it is now published. Readers of the Magazine will share our pleasure in the fact that both Mr. Wallis, who was intimately associated with Symons for a period of twenty-eight years, and Dr. Mill his successor as Director and Editor of the Magazine, are able to join with us on this occasion in doing honour to the memory of our founder.

The Scientific Work of George James Symons, F.R.S.

Symons was born on August 6th, 1838, in the spring of the nineteenth century when the new spirit of research and discovery was stimulating youth to make of the Victorian era from its outset a triumph of effort and optimism.

He grew up along with the growth of all that distinguished his century from those that went before—the strength of steel, the power of steam, the instantaneity of the electric telegraph and the blossoming of all the specialized Societies which promoted science and its practical applications. It was as natural for a quick-witted sympathetic boy finding himself in such a field of intellectual force to feel drawn towards science as for a magnet to swing towards the north. Had he received the discipline of thorough scientific training before he entered on scientific work he might have become one of the greatest men of science of his time. As it was, after a fair education at private schools and a brief course at the School of Mines he joined the recently founded British Meteorological Society at the age of eighteen, took part in the discussions in the following year and read a paper on thunderstorms before he was twenty. I doubt if he ever grasped the value of mathematics or the importance of theoretical reasoning. His mind was objective, guided always by shrewd common sense and impelled by an undying fire of enthusiasm. He was essentially a collector of facts, a keen critic in the cause of accuracy and a faithful chronicler of things as he found them. The results he obtained interested him in their application to practical affairs rather than in their bearing on scientific principles. At the age of twenty-two he attracted the attention of Admiral Fitzroy, famous for his voyage with Darwin in the *Beagle*, and obtained a post under him as a clerk in the Meteorological Department of the Board of Trade, which was the humble chrysalis whence the Meteorological Office of the Air Ministry eventually emerged. Symons found the type of office routine to which the name of Red Tape is applied particularly irksome because it cramped his scope. In the course of his official duties he was struck by the extreme inadequacy of the available observations of rainfall. So he proceeded to make a systematic collection of all those he could find, and appealed to the public for additional observers. This was not considered a suitable subject to occupy official time and, stung by the reproof of his superiors, young Symons resigned from the service of the State. In perfect freedom his genius for classification and organization drove him forward like a discoverer in a new world. His shrewd common sense controlled his enthusiasm and enabled him to devise methods of computation, checking and book-keeping which, while rigidly thorough, were so economical of space and time that he was able as years went on to maintain personal contact with his growing army of observers and to guide them into habits of order and accuracy, without himself neglecting an item of routine. With it all he developed a power of making friends with people of all social grades and of every mental range from the most eminent men of science to the merest dabblers in harmless hobbies.

Unquestionably the greatest contribution which Symons made to Science was the foundation and the building-up of the British Rainfall Organization with its annual publication, *British Rainfall*, and its journal, *Symons' Monthly Meteorological Magazine*.

In *British Rainfall*, 1860–61, there were records of 472 stations using instruments of widely different patterns, set at different heights above the ground, read at various hours and recorded often to different dates. *British Rainfall*, 1899, with the last records he collected gave results from 3,501 stations measured in rain gauges of approved and practically uniform pattern, set with very few exceptions at the uniform height of 1 foot, read in the case of daily gauges, which most of them were, at 9 a.m. and dated for the commencement of the 24 hours preceding the reading.

This close approach to systematic uniformity was the result of continuous research and supervision. Some idea of the vast amount of work done by Symons and those whom he directed may be obtained from " The Development of Rainfall Measurement in the last forty years " in *British Rainfall*, 1900, where references are given to many long series of experiments carried out to determine the best material, form and exposure of rain gauges, together with special studies to provide definitions of terms used in describing rainfall and the investigation of remarkable cases of heavy or continuous rains and of droughts.

Profiting by the lessons of past experience Symons made every issue of *British Rainfall* better than its predecessor and gradually brought his army of helpers to work together and accumulate a vast store of mutually interdependent data.

Much, perhaps most, of Symons's work embodied in these publications escaped cataloguing, but he is credited in the Royal Society's " Catalogue of Scientific Literature " with 46 entries. These deal largely with rainfall matters but they have a much wider range. He made a remarkable collection of books on meteorology dating from the earliest times, which on his death was added to the library of the Royal Meteorological Society and together with the Bibliography of Meteorology, on which he spent much time, is invaluable to the student of the history of weather science. In many other ways he did much to enhance the reputation of the Royal Meteorological Society in which he delighted to serve in every honorary office from Secretary to President. He made collections and catalogues of all varieties of meteorological instruments from the most primitive attempts to modern recording apparatus. He invented the Brontometer for the simultaneous record on a quick-running drum of barometric pressure, temperature, wind and rainfall with means for adding by hand the moment when lightning flashes were seen and thunder heard. Preliminary observations with this instrument were given in a paper to the Royal Society in 1890.

Whirlwinds, which had a peculiar fascination for him, snow-storms and floods formed the subject of many papers, his interest centering in their locality, incidence and effects, rather than in their cause. Except for a map of average rainfall based on a short but singularly representative period Symons made little use of cartographical method, his monthly and annual sketch maps of departures from the average published in *British Rainfall* being mere diagrams.

His almost instinctive genius for the collection and interpretation of instrumental records extended beyond his special sphere of rainfall. For many years he laboured for the Underground Temperature Committee of the British Association collecting records from all parts of the world. His small but valuable monograph on the "Floating Island of Derwent Water" made it clear that the phenomenon was not a mere legend but a huge blister of the felt-like layer of vegetable matter on the bottom of the lake which at times was inflated by decomposition gases until it appeared like a green islet on the surface.

His largest undertaking was the investigation he carried out for the Royal Society of the distribution of the dust from the volcanic outburst of Krakatoa in 1883 which he traced throughout the whole atmosphere all round the world. The report fills a substantial volume of the Transactions of the Royal Society and is a fine example of the large-scale expression of Symons's peculiar genius.

One cannot speak of Symons's work without a word about his attractive personality. His fresh complexion, prematurely white hair and beard, and especially his kindly humorous eyes made him a conspicuous figure at all scientific gatherings. I seem to see him still as I used to see him fifty years ago in the crowded receptions of the British Association passing from group to group of old friends with the button of the Legion of Honour in his coat and a smile of complacent geniality. He had always something pleasant to say and delighted in telling good stories and dropping hints helpful to young observers. He was always ready to act on committees and he always found time to answer letters with the promptitude of a busy man and the clearness natural to a well-stored mind and retentive memory. His loyalty to old friends was a feature of his character, and he gave a fine instance of it in his life-long association with a friend of his boyhood who became a printer and produced every volume of *British Rainfall* and every number of the *Meteorological Magazine* for more than half a century.

Symons had a wide knowledge of human nature and amazing tact in dealing with and getting the best out of people of every kind.

HUGH ROBERT MILL.

Style in Meteorological Literature

BY ELIZABETH KIDNER

Nowadays the pursuit of meteorology does not tend to inspire the highest flights of penmanship. A modern meteorologist is concerned mainly with calculations and in the exposition of these it remains only for him to aim at such austere qualities as brevity, lucidity and undeviating accuracy. When the science was in its infancy, however, it was the pet of philosophers and nature lovers, and the meteorological writings of those times are the result of an intense appreciation of the phenomena on which they treat, which produced a generally high standard of descriptive composition. The following account of a sea-breeze is taken from Dampier's "Discourse on Winds"[1] :—

"It comes in a fine, small, black Curle upon the Water, whenas all the Sea between it, and the shore not yet reach'd by it, is as smooth and even as Glass in Comparison ; in half a Hour's time after it has reached the shore it fans pretty briskly, and so increaseth gradually till 12 a Clock, when it is commonly strongest, and lasts so till 2 or 3 a very brisk gale ; about 12 Noon it also veres off to Sea 2 or 3 Points, or more in very fair Weather. After 3 a Clock it begins to dye away again, and gradually withdraws its force till all is spent, and about 5 a Clock, sooner or later, according as the Weather is, it is lull'd asleep, and comes no more till the next Morning."

Another example may be quoted from the Rev. W. Derham, whose annotated sermons, covering the whole field of natural history, are contained in a volume of " Physico-Theology "[2] :—

" By Reflecting the Light of the heavenly Bodies to us, I mean that Whiteness, or Lightness which is in the Air in Day-time, caused by the Rays of Light Striking upon the Particles of the Atmosphere, as well as upon the Clouds above, and the other Objects beneath upon the Earth. To the same Cause also we owe the Twilight, *viz.*, to the Sun-beams touching the uppermost Particles of our Atmosphere, which they do when the Sun is about Eighteen Degrees beneath the Horizon. And as the Beams reach more and more of the Airy Particles, so Darkness goes off, and Day-light comes on, and encreaseth."

These authors did not disdain to classify and to make laws, but their rulings were based on pictorial and naturalistic considerations which make them very pleasant reading. This is Francis Bacon's primary division of the winds[3] :—

" Windes are either generall or precise, either peculiar, or free. I call them generall which always blow ; precise, those which blow at certaine times : Attendants or Peculiar, those which blow most commonly : Free Windes, those which blow indifferently, or at any time."

This is Robert Boyle's idea of cold[4] :—

" We made three Differences of the Cold, all according to the Places : In our House, in the Woods, and in the open Air."

And here is one of the Shepherd of Banbury's rules[5] :—

" In Summer or Harvest, when the Wind has been South two or three Days and it grows very hot, and you see Clouds rise with great white tops like Towers, as if one were upon the Top of another, and joined together with black on the nether Side, there will be Thunder and Rain suddenly."

Much of the literature of that period is filled with the sense of mystery and portent which for many people even now accompanies the experience of the more violent freaks of the weather. Thus Daniel Defoe in his account of the great storm of November 26th, 1703[6] :—

" The wind by its unusual Violence made such a noise in the Air as had a resemblance to Thunder ; and 'twas observ'd, the roaring had a Voice as much louder than usual, as the Fury of the Wind was greater than was ever known : the Noise had also something in it more formidable ; it sounded aloft, and roar'd not very much unlike remote Thunder" . . . . "In the Countries the Air was seen full of Meteors and vaporous Fires: and in some places both Thundrings and unusual Flashes of Lightning, to the great terror of the Inhabitants."

In contrast to this is the dramatic effect achieved by Gilbert White by totally different means. Though employing the most unpretentious language, and confining himself usually to a statement of observational facts, he nevertheless contrives to hold his reader in a fascinating state of expectation. The following is an extract from his letter to the Hon. Daines Barrington describing the frost of January, 1776[7]:—

"On the fourteenth, the writer was obliged to be much abroad; and thinks he never before, or since, has encountered such rugged Siberian weather. Many of the narrow roads are now filled above the tops of the hedges; through which the snow was driven in most romantic and grotesque shapes, so striking to the imagination, as not to be seen without wonder or pleasure. The poultry dared not to stir out of their roosting places; . . . ."

Gilbert White's letters must rank among the very best of weather records. The simplicity and sincerity with which he writes constitute a very charming and dignified style.

During the nineteenth century meteorological literature gradually assumed a more and more strictly scientific aspect. Ruskin, however, for whom the scenic qualities of meteorology had much attraction, was grateful that his mind was still "capable of imaginative vision and liable to the noble dangers of delusion," and he contributed several papers from which many beautiful passages could be quoted. This is perhaps one of the best[8]:—

"But it (meteorology) is a science of the pure air, and the bright heaven; its thoughts are amidst the loveliness of creation; it leads the mind, as well as the eye, to the morning mist, and the noon-day glory and the twilight cloud,—to the purple peace of the mountain heaven,—to the cloudy repose of the green valley; now expiating in the silence of the stormless aether,—now on the rushing of the wings of the wind. It is indeed a knowledge, which must be felt to be, in its very essence, full of the soul of the beautiful."

Robert Louis Stevenson was the author of a meteorological paper and the following extract illustrates the lucidity with which he propounds his theme[9]:—

"In the first place, then, the mass of foliage may be expected to increase the radiating power of each tree. The upper leaves radiate freely towards the stars and the cold inter-stellar spaces, while the lower ones radiate to those above and receive less heat in return; consequently, during the absence of the sun, each tree cools gradually downward from top to bottom."

From the mass of modern meteorological literature, Mr. G. J. Symons's writings stand out by virtue of the freedom and vigour of his style and his frequent use of comparisons to emphasize his point. For example[10] :—

" Years ago, when the Meteorological Office was shut up from the afternoon of Saturday to the morning of Monday, I urged that it was impossible to avoid one of two alternatives. Either storm warnings were useful, in which case it was as wrong to stop them on Sunday as it would be to extinguish every lighthouse lamp on Saturday night, or they were useless and therefore should be abandoned entirely."

Mr. W. H. Dines wrote in a more conventional manner, with faultless composition and also with great clarity. For instance[11] :—

" Taking the earth's atmosphere as a system by itself, its angular momentum remains practically constant from year to year about the earth's axis : therefore the total couple due to all the forces acting upon it must be zero. The internal forces have no effect upon the system as a whole, and the only external force is that due to friction with the earth's surface ; hence the total moment caused by friction between the air and the earth, that is, the total moment caused by the friction due to wind, is zero."

For still more sedate prose and perfect phrasing we turn to Dr. H. R. Mill[12] :—

" Everywhere the effects of the dry season remained apparent, and more than once extraordinary clouds, the position of which in any classification would have been extremely troublesome, revealed themselves on a nearer approach to be swarms of locusts."

For a maximum of content into a minimum of words we look to Sir George Simpson[13] :—

" . . . very few educated people would have any difficulty in giving an answer to the question—What is the cause of the monsoon ? They would refer to the high temperature over the land compared with that over the surrounding sea, and would speak of ascending currents of air causing an indraft of sea air towards and into the interior of the country."

And for a new light on a well-worn subject we can always rely on Sir Napier Shaw[14] :—

" Two things are unconquerable in the long run, sand and snow, and sand is a sort of snow that never melts."

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[2] W. Derham. " Physico-Theology ", footnote, p. 12. London, W. Innys, 1719.

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[4] Robert Boyle. " The general history of the air ", p. 167. London, A. and J. Churchill, 1692.

[5] John Claridge. " The Shepherd of Banbury's Rules ", p. 27. London, Thomas, Hurst, Edward Chance & Co., 1827.

[6] Daniel Defoe. " The Storm : a collection of the most Remarkable Casualties and Disasters which happened in the Late Dreadful Tempest both by Sea and Land " , p. 34. London, J. Nutt, 1704.

[7] Gilbert White. "The Natural History of Selbourne", p. 292. London, Harry G. Bohn, 1851.

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[14] Sir Napier Shaw. "The drama of the weather", p. 54. Cambridge University Press, 1933.

Halo Phenomena of May 1938

Unusual halo phenomena were reported on two occasions during May. On the 1st Mr. W. F. Watson observed the display shown in fig. 1 at Aberdeen. He writes :—

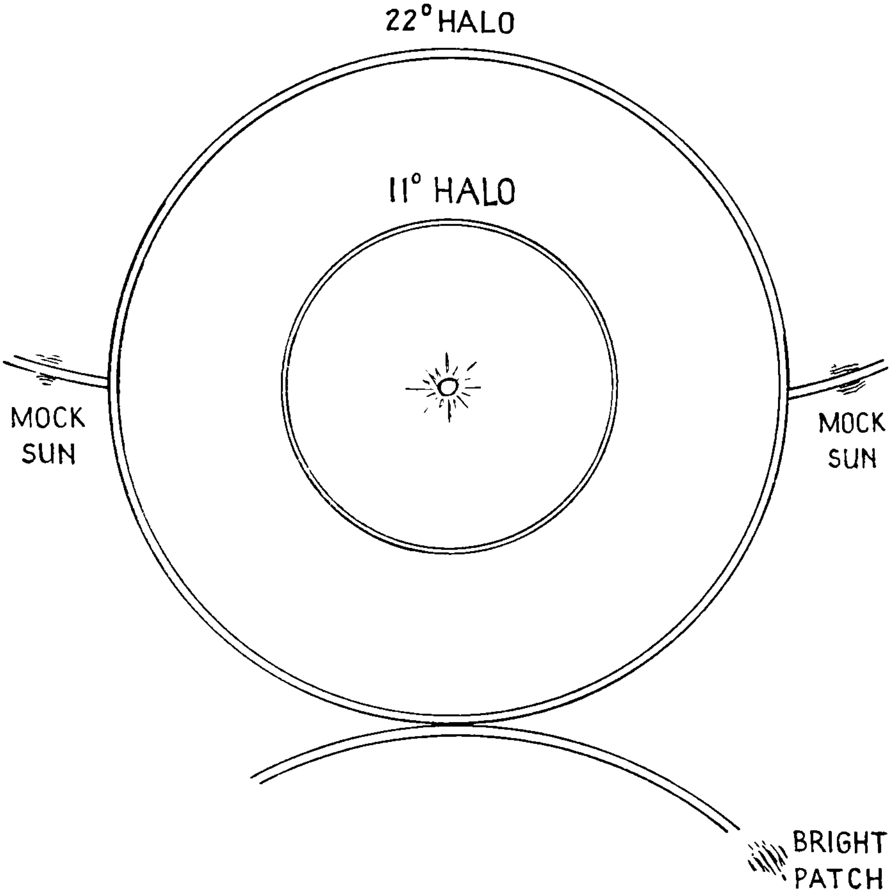

FIG. 1—HALO PHENOMENA, MAY 1ST, 1938, OBSERVED AT ABERDEEN

> "At 1220 G.M.T. an unusually brilliantly coloured 22° halo was visible. In this connexion it is interesting to note that with the exception of some cirrus wisps and about two-tenths of cirro-stratus in the eastern section of the sky, no cloud whatsoever could be seen in the vicinity of the halo (the sky being definitely blue). In addition to the 22° halo small portions of the parhelic ring, with colourless parhelia to right and left of the sun, were also visible outside the 22° halo. By 1225 G.M.T. a much smaller ring of approximately 11° radius could be clearly seen within the 22° halo. This small ring showed colours in the sequence—red nearest the sun, then yellow and a faint whitish, precisely as did the larger halo. The phenomenon was still visible at 1300 G.M.T. when the lower arc of contact became plainly visible with a brighter patch at its termination as shown in the accompanying sketch."
>
> "The small ring of 11° radius had disappeared by 1305 G.M.T. but was again seen for a short period at 1340 G.M.T. The 22° halo was visible until approximately 1400 G.M.T. when it too had disappeared. During the course of the afternoon although the halo itself was not seen again, the arc of upper contact with faint colour effects was noted at 1500 G.M.T., and the circumzenithal arc with strong colours was visible at 1700 G.M.T. for some twenty minutes."
>
> "The cirrus cloud noted during the afternoon underwent many changes, at times only the halo or arc indicated the presence of a very thin sheet of cirrus, at other periods typical banded and tufted cirrus with striated cirro-stratus appeared and covered up to six-tenths of the sky."

The display was also observed by Mr. G. A. Clarke who confirmed that the radius of the small halo was about 10° or 11°, and stated that it appeared thinner than the 22° halo and of about half the brightness.

This observation is of very great interest, and may be unique. No record can be found of any observation in which the radius of a halo was found by actual measurement to be between 10° and 11°. The nearest approach is that termed by L. Besson "Van Buijsen's halo," which has been recorded eight times, with estimated radii varying from 7½° to 10° and an average of 8½°. A display somewhat similar to that at Aberdeen was sketched by Mr. S. C. Russell at Epsom in 1907,* but no measurements are given and the figure of 10° given by Besson for the small halo was apparently measured from the sketch. Mr. Clarke estimated the radius of the halo at Aberdeen with the aid of a scale and black mirror, and is most unlikely to have been two degrees out. There is good reason therefore to regard this as a hitherto unknown halo phenomenon, for which the name "Clarke-Watson halo" is suggested.

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* *Symons' Met. Mag., London*, 42, 1907, p. 35.

The second display was on May 30th, when Mr. G. A. Clarke achieved the rare if not unique feat of obtaining good photographs of elliptical halo. Mr. Clarke's account of the display follows :—

> " A rather remarkable series of optical phenomena in a sheet of cirro-stratus cloud was observed at Aberdeen on the morning of May 30th."
>
> " As early as 7h. G.M.T. a very bright upper arc of contact to the halo of 22° was observed, the halo itself being faint and incomplete. At 8h. a lower arc of contact had also become visible and two parhelia, fairly bright and well extended horizontally, but narrow vertically were seen while the halo itself though still very faint was distinguishable, the appearance being as shown at I in fig. 2. The arcs of contact were very bright and at first were rather broad and diffuse, but as time went on they became narrower and more sharply defined, as well as even more brilliant in intensity. Colours from the orange-red through green to blue-green were clearly evident, and occasionally a blue-violet was faintly discernible, the background of cirro-stratus cloud being of a greyish rather than of the usual milky tint."
>
> " At 8h. 15m. a faint parhelic (or mock sun) ring was formed, extending from the parhelia round the sky, and for short periods this ring could be very faintly seen within the halo itself.

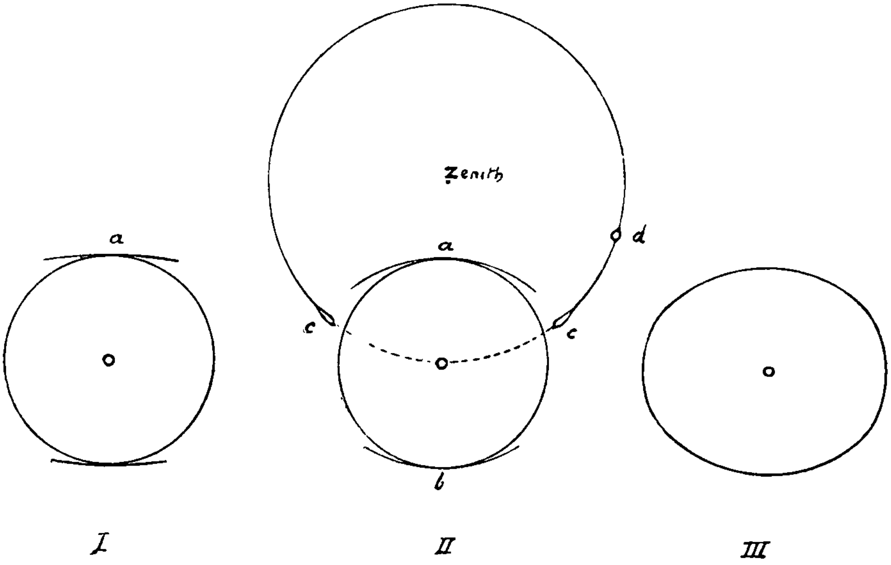

FIG. 2—HALO PHENOMENA, MAY 30TH, 1938, OBSERVED AT ABERDEEN

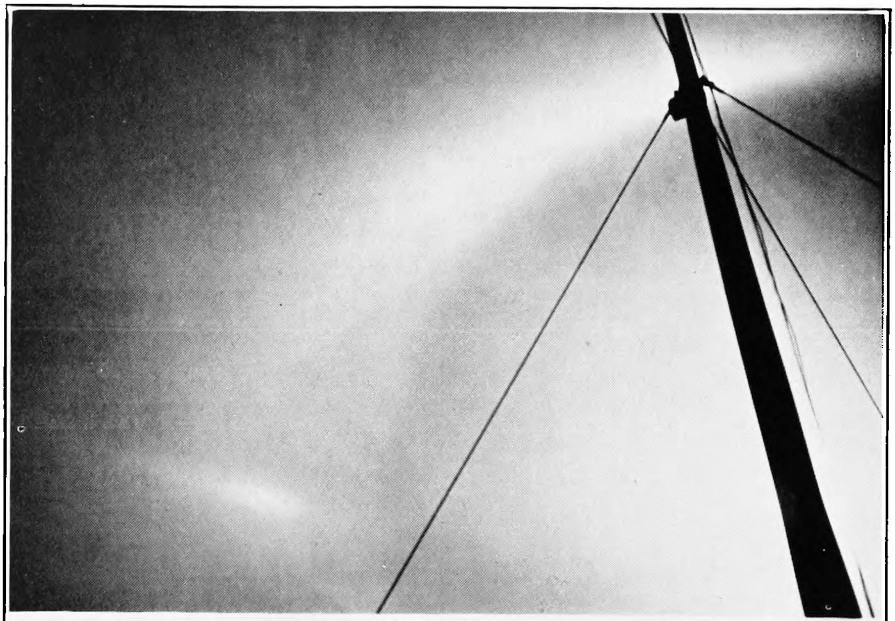

Fig. 3

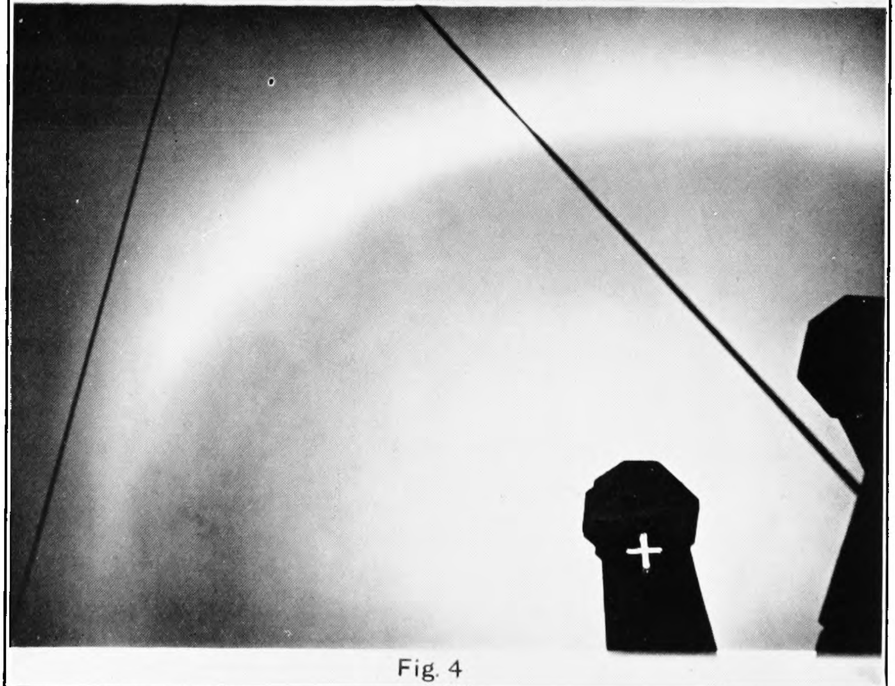

Fig. 4

Copyright G. A. Clarke

FIGS. 3 AND 4.—ELLIPTICAL HALO, MAY 30TH, 1938, OBSERVED AT ABERDEEN

The parhelic ring then disappeared but formed again later, and after 9h. the general appearance was as shown at II in fig. 2. The contact arcs *a* and *b* had become more concave towards the sun, the parhelia ring *cde* was complete outside the halo of 22° and just barely traceable within it; there was a white (or colourless) parhelion at *d* where the halo of 46° should normally intersect the parhelic circle, though there was no trace whatever of the 46° halo itself. The two parhelia *c* were bright and strongly coloured, and the arc *a* was brilliant and also strongly tinted."

"After some time the parhelic circle finally disappeared and the arcs *a* and *c* gradually extended until they met in the neighbourhood of the parhelia. These latter then disappeared, together with the last traces of the 22° halo, and there was left visible an extremely fine elliptical halo whose upper and lower arcs were intensely brilliant, while the sides were fainter, but quite clear and so easily discernible even to the layman that the phenomenon was noted and commented upon by numbers of the general public (*see* III in fig. 2)."

"The phenomenon was observed by all members of the local staff, and while photographs were being taken by myself, measurements by theodolite were being made by Mr. Inman, and notes of the changes in form and intensity of the various phases by Mr. Watson."

"Measurements by theodolite gave the major axis of the ellipse as 27°, agreeing with my own estimate, and corroborated by the photographs (figs. 3 and 4) accompanying this note. On the chimney is a white cross, this represents the actual position of the sun. If a scale is placed on the photograph it will readily be seen that the distances from the cross to the top of the arc and from the same point to the lower end of the arc are in the ratio of 22 : 27."

"The sheet of cirro-stratus in which these appearances were observed was of a rather peculiar type. The brilliant halos are most often seen (in the writer's experience at all events) in sheets of structureless pale milky-tinted 'cirro-nebula'—as it used to be named—but on this occasion the cloud layer showed a strange curdled or turbulent structure, a little of which may perhaps be seen in the reproduction of the photograph just with the arc near its lower end; the structure is much more clearly shown in other photographs of the series I made."

On the afternoon of the same day another remarkable display was observed at the Bidston Observatory, Birkenhead. Mr. R. H. Corkan writes:—

"The phenomena were first noticed after they were well formed, at about 14h. 20m. G.M.T. and consisted of a complete 22° halo, a complete mock sun ring and two brilliant parhelia just outside the 22° halo. The parhelia and halo were coloured with red towards the sun. At about 14h. 45m. G.M.T. the upper and lower portions of the halo commenced to fade and there formed first the upper portions and later the complete ring of a 17° to 19° halo, also coloured with red towards the sun. The portions of the 22° halo near to the mock sun ring and their associated parhelia remained bright, while between the two halos was formed a diffusion of light, which, at a casual glance, caused the whole to have the appearance of a circle and an ellipse concentric with the sun, the two being tangential at their upper and lower parts. The large separation between the parhelia of the 22° halo and the inner halo was a striking feature of the display."

" Shortly after, there appeared on the mock sun ring, which was still complete, two large white parhelia at 90°. Anthelion was not observed. The whole remained practically unchanged in form until well after 15h. G.M.T. when the halos began to fade. The mock sun ring and the parhelia still remained bright and were visible until about 15h. 40m. G.M.T."

The halo of 17 to 19 degrees, known as Rankin's halo, is extremely rare, probably less than a dozen records of it being known. A very fine example was seen in south-east England on May 16th, 1926, when accurate measurements by C. J. P. Cave gave a radius of 17½° to the inner edge.* It was probably seen in Cumberland on May 8th, 1935,† but no exact measurements were made. It is a remarkable coincidence that two halos, one very rare, the other possibly unique, should be observed in Great Britain in the same month.

OFFICIAL PUBLICATION

British Rainfall 1937. H.M. Stationery Office, 15/- net.

The seventy-fifth volume of British Rainfall follows the general lines of its predecessors and includes the usual detailed discussion of the rainfall of the year in all its aspects. A new feature is an Index of River Basins, which has been added as a supplement to the alphabetical index of counties, and should prove very useful to readers who wish to survey all the rainfall readings available for a given basin. Part IV includes two special articles by Dr. Glasspoole, and one by Miss Lewis. It is a pleasure to record that in the Symons centenary year the volume has been produced at an exceptionally early date.

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* *Nature, London*, 117, 1926, p. 791.

† *Met. Mag., London*, 70, 1935, p. 130.

Correspondence

To the Editor, *Meteorological Magazine*

Divergent Isobars and Winds

In the discussion of this subject[1] the dry periods in 1921 and 1933 have been referred to. The published charts of mean pressure for these dry periods show that in 1921 and 1887[2] a wedge-shaped area of high pressure extended from the Azores area to Southern England, while in 1933[3] a similar wedge extended to France. The effect of curvature in the air motion would be to cause slight convergence on the north side of the wedge, but in practice the divergence due to surface friction might entirely overcome this. The interesting fact so well brought out in Dr. Frith's diagram[1], that with steep gradients the actual wind at 2,000 feet averages much below the geostrophic value, is likely to result partly from a predominance of cyclonic curvature when the gradient is steep and partly from friction. In very turbulent air surface friction affects the wind at 2,000 feet, but over the sea a sufficiently high degree of turbulence is unlikely. Thus Dr. Frith's diagram has probably no application to the conditions in the droughts of 1921 and 1933, where the steep gradients were on the Atlantic, with little curvature in that area.

The daily charts in 1921 and 1933 show periods when anticyclones formed over the British Isles, and divergence was to be expected, and the other fine periods were probably due to previous subsidence in the air mass. A persistent area of high pressure is a complex affair built up of component parts, each of which has a period of development with subsidence. This produces dryness aloft and reduces the lapse rate, and in conjunction with other factors usually causes an inversion or very stable layer which is not readily destroyed, so that eventually the large high pressure area is occupied entirely by stable air which is dry aloft. There may be stratus or stratocumulus clouds, but these tend to dissolve as the air spreads inland and is heated from below, the amount of cloud being obviously influenced by the strength of the wind, the length of its track over land, and the time of day. Minor fronts between the old and new parts of the anticyclone can produce little or no precipitation in these conditions, apart from drizzle near the coasts.

Many individual cases of fine weather associated with diverging isobars can be explained by the above considerations. The association is by no means invariable, since a wide frontal rain belt not infrequently extends into a region of diverging isobars in the cold air.

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[1] *Met. Mag., London,* 73, 1938, pp. 119–121.

[2] C. E. P. Brooks and J. Glasspoole. "The Drought of 1921". *London, Quart. J.R. Met. Soc.*, 48, 1922, p. 139. (Figs. 19 and 20, p. 158.)

[3] J. Glasspoole and W. L. Andrew. "The Exceptional Summer of 1933". *London, Quart. J.R. Met. Soc.*, 60, 1934, p. 29. (Fig. 16, p. 51.)

Before there can be any serious challenge to the theorist, the empirical case for the fanning of the isobars being a cause of divergence of air needs to be established. To prove or disprove it satisfactorily from pilot balloon data may be impossible, but the calculation of subsidence from observations of upper air temperature and humidity provides a practicable alternative.

C. K. M. Douglas.

Meteorological Office, London, July 28th, 1938.

Thunderstorms at Market Harborough, July 1st, 1938

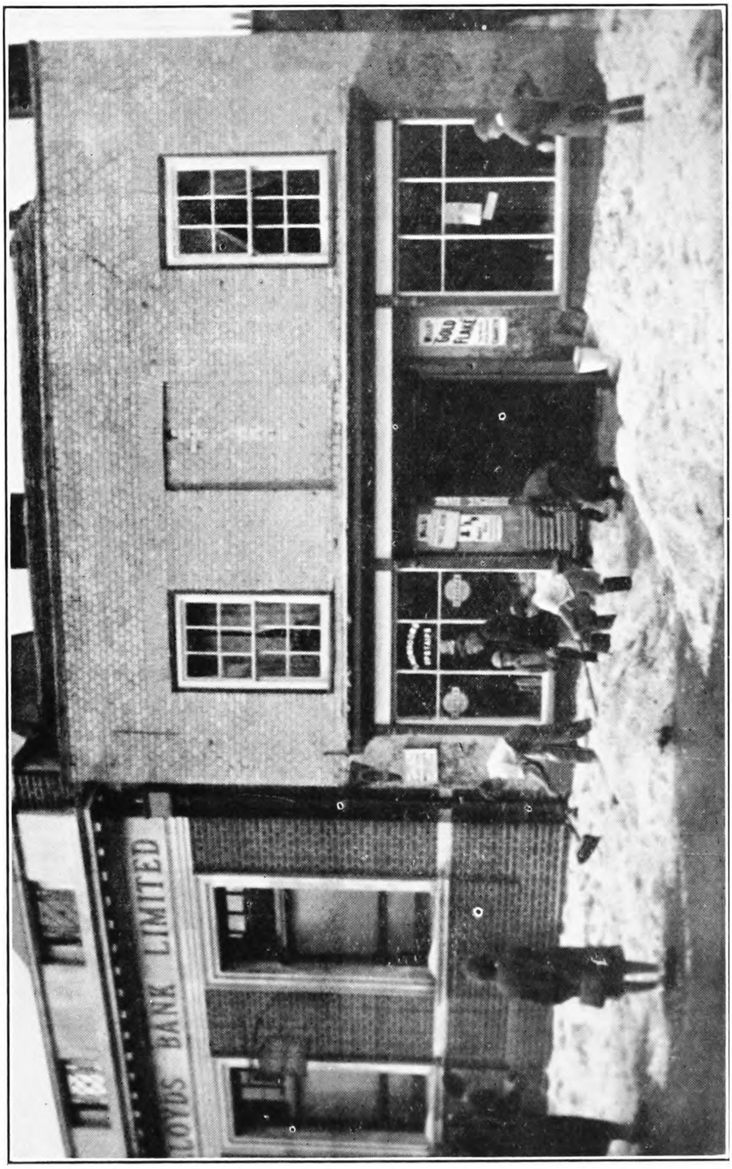
On July 1st, 1938, from 1620 to 1815 G.M.T., two thunderstorms were more or less simultaneously in progress here, accompanied by intense rainfall. One storm, approaching from the S.W., preceded the other, from the E.N.E., by some ten or twelve minutes, and the former was virtually overhead from 1720 to 1725 G.M.T., while the nearest approach of the later storm was about 1 mile away to the E. at about 1755 G.M.T. There was considerable lightning and thunder during the period, but by no means exceptional or severe. The truly remarkable feature was the intense rainfall, reaching maximum downpour about 1720 to 1730 G.M.T. Hailstones of moderate size, diameter 1·0 to 1·5 cm., fell for several minutes during the maximum period. From about 1755 to 1805 G.M.T. the sun shone brightly through breaks in the clouds and a rainbow was noticed. Shortly after the cessation of rain, I measured the amount of rainfall recorded in my 5 in. rain-gauge, standard M.O. pattern, the amount being 1·95 in., the whole falling in approximately two hours.

This morning (July 2nd), my garden shows the force of this heavy rainfall in various ways ; a flat portion of the kitchen-garden has the clear pressed appearance of the sea-beach after the tide has receded ; some rows of potatoes, " moulded up," were washed nearly flat and one potato " set " was lying exposed above the ground ; small seedlings of wallflowers, etc., were washed out of their seed-beds ; and across a sloping portion of the kitchen-garden channels 3 or 4 inches deep and several yards in length were cut by the rushing streams, while the hollows at the edge of a lawn and of grass-paths were choked with several inches of finely-washed sediment.

A remarkable feature of this intense downpour of rain is the fact of the restricted area upon which it fell. My house is on the extreme eastern boundary of the town, on a hillside 356 ft. above sea-level. About three-quarters of a mile westwards, at the offices of the Urban District Council, the rainfall read at 900 G.M.T. this morning was 0·75 in., about half a mile further westward the rainfall reported by Mr. G. C. Wooldridge was 0·52 in., and at the Grammar School, about one and a half miles N.W. from here, the amount was 0·64 in.

P. J. Harris.

Hillcroft, Shrewsbury Avenue, Market Harborough, Leicestershire, July 2nd, 1938.


LOYDS BANK LIMITED

LARGE HAILSTONES AT BISHOPS WALTHAM, JULY 7TH, 1938

Hailstorm at Eastbourne, July 7th, 1938

Distant thunder first heard about 4 p.m. B.S.T. Thunderstorm occurred from 4.55 p.m. to 5.15 p.m. B.S.T. which was accompanied by heavy hail from 5.5 p.m. to 5.12 p.m. B.S.T. The sky cleared immediately after this and the sun came out but at 5.25 p.m. B.S.T. a heavy shower occurred and lasted for 3 or 4 minutes. The total amount measured at 17 hour was 0·465 inch. No precipitation occurred before the commencement of the storm at 4.55 p.m. The hailstones resembled in shape that of a kidney bean or a section of a tangerine orange. They were hard, grooved and round on the inner and outer edges. The average size was that of a sugar lump or moth ball. One I picked up was about ¾ inch long and ½ inch wide. Considerable damage was done but this was confined chiefly to gardens. In my own garden the stems of a row of dwarf peas which had not been stuck and were about 12 inches high were cut in half, the pods in other rows were badly scored, the leaves of the sprouts were riddled and the lettuce plants had their outside leaves cut off. The tops of the potatoes, chrysanthemums and the carnation shoots were cut off.

A. H. HOOKHAM.

Avenue House, The Avenue, Eastbourne, July 26th, 1938.

Hailstorm near Winchester, July 7th, 1938

On July 7th, 1938, at about 5.0 p.m. B.S.T. South Hampshire experienced a very severe thunderstorm that did an immense amount of harm to market gardeners and farmers. It was quite unique to residents in the area, and had not been experienced for at least a century.

It was accompanied by hail which was a foot deep in the Square at Bishops Waltham, near Winchester, where the accompanying photograph was taken (facing page 179).

The hailstones were one inch in diameter and the size of napthalene (moth) balls. There was a wind with the storm which blew in gusts of 50 m.p.h. at the height of the disturbance.

NORMAN E. NEVILLE.

83, *West Street, Fareham, July 16th,* 1938.

Great Gale of June 1st, 1938

On Wednesday, June 1st, a squally S.W. wind was blowing over the Isle of Wight, and towards evening this increased rather suddenly. Before darkness set in, a tempest of unprecedented fury was raging, the wind increasing to about 90 m.p.h. in squalls. Next day it was possible to see the havoc caused by this extraordinary June gale. All trees facing windward, that is to say south-west, especially in exposed places, were quite brown and withered, just as if fire had swept over them. On the leeward side, however, the trees retained their usual greenness, so that the effect was most unusual. This blasting of trees, shrubs and flowers, alike, was caused by the salt spray carried far inland by the wind, and for miles this sorry sight was apparent. My father who has lived in the Wight for more than 50 years, says he never remembers such a sight before in mid-summer, though in September, 1935, a violent gale had the same effect on vegetation—but it was autumn then, so the picture was not nearly so incongruous. Another S.W. gale, fortunately not so violently destructive, broke over the Island on June 28th, and this naturally aggravated the situation. It must be many years since June has been so windy in the Wight. We have had extremely dry weather ever since February 1st, and this may have helped to irritate the already parched leaves. The rainfall at Sandown for the first half of 1938, January–June, is only 6·38 in., a 30 year record at least.

J. E. COWPER.

Shanklin, July, 1938.

(*Note.*—The damage to foliage noted by Mr. Cowper occurred over a very wide area. It is not certain that it was occasioned by salt spray ; the fact that it occurred in all cases on the weather side of the trees rather suggests that the browning was due to mechanical damage caused by the buffeting of the wind.—Editor.)

Unusual Records of Temperature and Vapour-Pressure

I think the following abnormal recordings here (height above M.S.L. 105 ft.) may be of interest to your readers.

On July 1st the absolute minimum temperature recorded in a Stevenson Screen was 38° F. The temperature remained below 40° F. for 3 hours.

On July 31st at 18h. G.M.T. the dry bulb thermometer read 69·0° F. and the wet 68·0° F., giving a dew point of 67° F. and a vapour pressure of 22·9 millibars, very unusually high for so low a dry bulb temperature.

J. M. BRIERLEY.

Rodwell, South Petherton, Somerset, August 2nd, 1938.

NOTES AND QUERIES

Note on the trend of temperatures, 1880–1937

Meteorological literature of recent years shows that considerable interest in being taken in the marked upward trend of temperatures as observed in various parts of the world. This movement towards higher temperatures has become especially notable of late years in North Arctic regions[1], and also to a less extent in Europe[2], North America[3], Egypt[4], etc. In the following tables successive 20 year means of temperature, covering the last 55 years, are shown for a few representative stations where the readings are thought to be very reliable. The use of a few 20 year means in this way presents a very simple picture of temperature trend, and avoids the slight distraction caused by the minor fluctuations which are shown by " moving average " curves. The latter are of course preferable for a close study of weather elements.

Table 1 compares the period temperatures of Great Britain as recorded at the observatories of Oxford and Aberdeen with those observed at three stations situated in the countryside several miles from any town. The general agreement of the 20-year means is so good here that it gives real confidence in the accuracy of temperature measurements at the best meteorological stations. Incidently it shows that change of mean temperature at city stations, due to an increase in size of the city, is very small or absent at old established cities such as these.

TABLE 1

SUCCESSIVE 20 YEAR TEMPERATURE DEPARTURES AT CITY AND COUNTRY STATIONS IN GREAT BRITAIN

A = Combined mean at three English country stations (Stonyhurst College, Hodsock Priory and Rothamsted).

Period	1880–1899	1890–1909	1900–1919	1910–1929	1918–1937
	Mean	Departures from mean			
	° C.	° C.	° C.	° C.	2° C.
A	8·70	+·11	+·19	+·32	+·37
Oxford	9·25	+·10	+·19	+·32	+·36
Aberdeen	7·70	+·17	+·19	+·31	+·44

Table 2 shows the temperature trend from six stations between central Europe and the North Cape. As pointed out by Dr. Brooks[1] the later arrival of higher temperatures in the Arctic is very important in the study of the cause of recent variations in the far north.

TABLE 2

SHOWING LATER ARRIVAL OF HIGHER TEMPERATURES IN ARCTIC EUROPE

Period		1880–1899	1890–1909	1900–1919	1910–1929	1918–1937
Station	Lat.	Mean	Departures from mean			
	N.	° C.	° C.	° C.	° C.	° C.
Vienna	48	9·03	+·10	+·23	+·32	+·47
Berlin	52	9·09	+·14	+·34	+·43	+·60
Copenhagen ...	56	7·63	+·09	+·22	+·36	+·58
Helingsfors ...	60	4·42	+·06	+·14	+·31	+·70
Harparanda ...	66	0·71	–·04	–·06	+·27	+·88
Gjesvaer ...	71	1·86	·00	–·07	+·29	+·82

Table 3 gives the same period departures from different parts of the world. The 11 stations shown here appear to have thoroughly reliable records and may be taken as generally representative of the region in which they are situated. On the whole these regions show a marked similarity to the European temperature departures, but as would be expected there are considerable differences in the Tropics and Southern Zone. The west Pacific is a region where short period temperature departures are inclined to be opposed to those of Europe.

TABLE 3

TREND OF TEMPERATURES IN DIFFERENT PARTS OF THE WORLD, 1880–1934

Period	1880–1899	1890–1909	1900–1919	1910–1929	1915–1934
Station	Mean	Departures from mean			
	° C.	° C.	° C.	° C.	° C.
North Temperate Zone					
Sulina (Black Sea) ...	10·93	+·09	+·19	+·22	+·23
St. Louis, Mo. ...	13·20	+·19	+·15	+·29	+·60
Tokyo	13·82	−·01	−·05	+·19	+·30
Tropical					
Key West, Flo. ...	24·00	−·27	−·20	+·10	+·27*
Honolulu	23·73	−·22	−·13	+·10	+·15
Batavia	26·02	+·14	+·28	+·41	+·48
Allahabad	25·77	+·16	+·05	+·16	+·25
Lagos, Ni'j.	26·94†	·00	+·10	+·14	+·14
South Temperate Zone					
Cape Town	16·82	−·16	+·12	+·41	+·52
Santiago	13·50	+·26	+·28	+·16	+·25
Adelaide	17·23	−·06	+·01	+·13	+·13

* 1918–1937. † 1892–1909.

Most of the years of the present decade have been much above normal over wide areas ; notably in the Arctic, the whole of North America, most of Europe, South Africa, and the far south Atlantic at South Georgia. Small areas showing distinct negative departures of late are located in Portugal and the south east part of India.

G. S. CALLENDAR.

REFERENCES.

[1] C. E. P. Brooks. *London, Met. Mag.*, 73, 1938, p. 29.
[2] C. E. P. Brooks. *London, Met. Mag.*, 57, 1922, p. 203.
[3] J. B. Kincer. *Washington, Mon. Weath. Rev.*, 61, Sept., 1933.
[4] L. J. Sutton. *London, Quart. J.R. Met. Soc.*, 62, 1936.

REVIEWS

Agricultural Meteorology : The prediction of the minimum temperature on clear days at selected stations in India. By M. Narasimhan and L. A. Ramdas. Reprinted from *The Indian Journal of Agricultural Science*, Vol. VII, Part V, Oct., 1937. Delhi, 1937.

The object of this paper is to forecast the occurrence of frost for the agriculturalist and it seems to be assumed that a prediction of the screen temperature at a height of four feet fulfils that purpose. The paper is in two sections : the first a brief theoretical note on nocturnal cooling and the second a statistical examination of data from 19 stations throughout India. Neither section appears to have any real connexion with the other.

The authors quote Ångström's formula, $S/\sigma T^4 = A - B \times 10^{-\gamma e}$, for the ratio of incoming to outgoing nocturnal radiation with clear skies (e being the vapour-pressure), giving the values of the constants A, B and γ for Poona, although it may be remarked that Brunt's expression, $a + b\sqrt{e}$, for the same ratio gave a correlation coefficient of 0·93 for that station. This formula is then used somewhat naïvely as evidence that nocturnal cooling should be greater the drier the atmosphere. A uniform curve is also given, showing, for a chosen maximum temperature and for 17 stations taken together, a close and nearly linear relationship between the diurnal range of temperature and the vapour-pressure. This, however, is greatly at variance with the formulae evolved for individual stations later in the paper.

The statistical section of the paper proceeds on familiar lines to connect the minimum temperature (N°F.) with a preceding temperature and humidity by means of an empirical formula, the precise variables chosen being maximum temperature (X°F.) and vapour-pressure (V ins. mercury) recorded in the preceding afternoon. The months selected are mainly between November and March and extend over from one to five years so as to provide observations on 100 clear nights at each of the 19 stations. Dot diagrams are drawn between V and N, and between X and N, and the corresponding correlation coefficients are found to be of the order of 0·6 or 0·7. These relationships are finally combined in the regression equation, $N = b_x X + b_v V +$ constant, and the multiple correlations are all found to be above 0·7, the highest being 0·93 at Calcutta.

The 100 individual readings are given for Calcutta, with evidence that the same regression equation holds over several years taken individually. The error in the forecast minimum temperature is rarely greater than 3°F., but the wide range of values of the constants b_x and b_v at different stations raises a strong doubt as to whether the formula has much value in forecasting when the correlation coefficient is below 0·9.

Thus, for Bangalore,

$$N = -29{\cdot}91 + 0{\cdot}9568\,X + 3{\cdot}46\,V,$$

while, for Lahore,

$$N = 4{\cdot}96 + 0{\cdot}3692\,X + 35{\cdot}48\,V.$$

At both places there is a negligible correlation between X and V, so that water-vapour seems to be ten times as effective at the latter as at the former in reducing the fall of temperature. Apart from this inconsistency between most pairs of the 19 stations, such a result obscures any connexion with simple radiational reasoning.

Higher correlation might have been found if the vapour-pressure term had been $10^{-\gamma e}$ or $\sqrt{V}$, according as Ångström's or Brunt's formula is preferred. As it stands the equation is not very different from that deduced by Gold* from the observations of Andrews at

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* *Met. Mag., London,* 69, 1934, p. 88.

Larkhill, subsequently written by Flower and Davies* in the form

$$T - M = a(T - D) + bT + c,$$

where T = temperature at 15h.,
D = dew-point at 15h.,
M = minimum temperature on the following night

and a, b and c are constants.

Replacing T and M by the X and N of the present paper, the formulæ then only differ appreciably in that D is not exactly proportional to V, a discrepancy that increases with temperature. It is interesting to make approximate transformations from the mean values given in the paper in view of the suggestion put forward by Flower and Davies that a has a universal value of about 0·4 for all parts of the world. The values of a so found range from about 0·3 almost to zero, thus giving some support to Veryard's† conclusion that a decreases as the diurnal temperature range increases.

C. J. BOYDEN.

Étude pratique des rayonnements solaire, atmosphérique et terrestre (méthodes et résultats). By Ch. Maurain. Size 10 in. × 6½ in., pp. 189. *Illus.* Paris, Gauthier-Villars. 1937.

The study of the radiations from the sun, and their transformations within the atmosphere, has become a highly important branch of meteorological research, with an enormous literature of its own. Prof. Maurain has therefore performed a valuable service for meteorologists by providing a clear, readable and comprehensive account of our present knowledge of the subject.

After a brief chapter on the duration of bright sunshine, the author describes and illustrates the various instruments in general use for measuring the intensity of direct solar radiation, and discusses in detail the method of computing the "solar constant". The next chapter deals with the weakening of the solar radiation during its passage through the atmosphere and gives a great deal of information about the coefficient of transparency and factors of turbidity. In Chapter VI the study of incoming radiation is completed by an account of methods and measurements of radiation from the sky, while the following chapters deal with terrestrial radiation, the theoretical distribution of solar radiation over the globe (in this chapter several pages are devoted to Sir George Simpson's studies of radiation), the inter-relations between direct solar, sky and terrestrial radiation, and the general balance of radiation in the atmosphere and on the surface of the earth. Here it is of interest to find that the balance sheet formulated by W. H. Dines in his well-known paper on "The heat balance of the atmosphere", published in 1917, can hardly be improved upon after the accumulated research of twenty years.

The second half of the book deals with the spectral distribution of energy in solar and sky radiation, and like the earlier chapters describes first methods and then results. Several pages are given to the measurement of ultra-violet radiation, but the photographic method is dismissed in a few lines and Dobson's name is not mentioned. In Chapter XIII the author discusses the luminous intensity of solar and sky radiation and the intensity of daylight, and in the final chapter the climatic effects of solar heat and light, for example on the growth of plants. The book is mainly a summary of the work of others, but it is woven into a complete whole, and now and again the author interjects some thoughtful criticisms or considerations of his own. C.E.P.B.

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* *Met. Mag., London,* 69, 1934, p. 230. † *Met. Mag., London,* 71, 1936, p. 69.

The air and its mysteries. By C. M. Botley, F.R.Met.Soc. Size $7\frac{1}{2} \times 5$ in., pp. xvi + 296. *Illus.* London, G. Bell and Sons, Ltd., 1938. Price 8*s*. 6*d*. net.

As a frequent contributor to our correspondence columns the name of Miss Cicely M. Botley is well known to readers of the *Meteorological Magazine* and it is a pleasure to welcome a book from her pen. " The Air and its Mysteries " belongs to the "popular" class of scientific literature ; it is " an attempt to give those who live in an air-minded age some insight into the new and wonderful realm of which, through the courage of the pioneer and the skill of the scientist, they have been made free." The scope of the book goes far beyond the ordinary confines of meteorology and it contains a surprising amount of information on all sorts of subjects connected directly or indirectly with the air. As might be expected from Miss Botley, many of her 296 pages are enriched with interesting quotations from folk-lore and classical literature. There are numerous illustrations, excellently reproduced. The author has a well-stored mind and a fluent easy style. In a Foreword, Sir Richard Gregory expresses the view that the book is worthy of taking a high place among the many good books on scientific subjects now available to the non-technical reader. A few inaccuracies were noted, but we agree with Sir Richard's opinion and commend the book to the attention of those in search of light reading of a pleasant and informative character.

E. G. B.

BOOKS RECEIVED

County Borough of Eastbourne : Annual Report of the Meteorological Observations for the year 1937. Eastbourne, 1938.

County Borough of Southport : Meteorological Department : Report and Results of Observations for the year 1937. Southport, 1938.

City of Portsmouth : Health Report for the year 1937. (Meteorology, pp. 25–26), Portsmouth, 1938.

Borough of Torquay : Meteorological Report for the year 1937 *with extremes and comparisons with averages of preceding year.* Torquay, 1938.

OBITUARY

We regret to learn of the death of Lt.-Colonel C. H. H. Harold, O.B.E., R.A.M.C. (Retired), Director of Water Examination, Metropolitan Water Board, who died on 18th July, 1938, at the age of 53.

The Weather of July, 1938

Pressure was high (1028 mb.) west of the Azores and low (1003 mb.) over Baffin Bay, the low pressure area extending eastward to Scotland and northern Ireland (1010 mb.). Over most of Europe pressure was uniform, about 1015 mb., decreasing to 1000 mb. over the Red Sea area. In North America pressure was highest in British Columbia (1019 mb.). The differences from normal were generally slight but areas of 5 mb. above normal occurred in western Canada, west of the Azores, Finland and Iraq. The Atlantic west of the Azores and the Sudan were 5 mb. below normal. No figures were received from Russia, India or Australasia.

Temperatures were everywhere above 32° F. The British Isles with means ranging from 55° F. in the north-west to 62° F. in London were slightly below normal as were northern and western France, but Scandinavia with temperatures of about 60° F. was abnormally warm. In south-eastern Europe the temperatures of 70° to 80° F. were also from 3° to 5° F. above normal. In North America temperatures ranged from 35° in Baffin Bay to above 80° F. in the southern States; Texas was 5° F. above normal but elsewhere the deviations were small.

Rainfall in Europe was generally deficient, but above normal in most of Sweden, Ireland and parts of Britain, southern France and parts of the Balkans. In most of the United States rainfall was abnormally heavy, especially at Mobile (13 inches, nearly twice the normal) and Abilene (8 inches, 6 inches above normal). Central and southern Canada in general had deficient rains.

The weather of July was chiefly notable for the general deficiency of sunshine, and stations in Ireland had about 30 per cent. less than the average. It was wet generally over the British Isles as a whole, and another interesting feature was the large number of days with rain in the west and north. Although wet elsewhere, in south-east England and part of the Midlands July was the sixth successive dry month. Many stations in Ireland had excesses of over 50 per cent. of the average rainfall, while in Cumberland many places had more than twice the average rainfall, totals exceeding 20 inches at several stations and even exceeding 25 inches at one or two stations. Rainfalls of the same amounts were recorded on Snowdon during the month. Deep depressions on the 7th to 8th and from the 27th to 30th resulted in gales in western and southern coastal districts and a squall of 76 m.p.h. was recorded at Calshot during a thunderstorm on the 7th when heavy rain fell in Ireland and much damage was done to crops and trees locally in southern England, where hail accompanied the thunderstorm.

During the first two days of the month pressure was high to the south-west and low to the north-east of the British Isles: thundery conditions prevailed for the first week and thunderstorms and hail were reported on each of the first seven days. Temperatures were below average and continued so for the first half of the month. A depression centred south of Iceland on the morning of the 3rd moved east-south-eastwards reaching the Hebrides on the 4th and the low pressure area covered the North Sea, the British Isles and north-west Atlantic on the 5th. Sunshine totals were poor during this period, although higher totals were recorded in the south-west on the 5th. A depression south-west of Ireland on the 6th took an easterly and then northerly track, deepening as it progressed until it was situated over south Wales on the 8th: there were heavy falls of rain on the 7th, particularly in Ireland and among the highest totals recorded were 3·14 inches and 3·02 inches at Greystones and Roundwood respectively, both these stations being in Co. Wicklow. Stations in southern Scotland and north-western England had no sunshine on the 7th and gales were recorded at some stations on the 8th. The depression moved slowly north-eastwards on the 9th and pressure rose temporarily over the British Isles. From the 10th to 12th a series of depressions moved eastwards across Scotland and sunshine totals were very low, some stations recording no sunshine on one or other of these days. There were general showers on the 10th and 11th in the north and west and fog was reported at several coastal stations during this period.

A ridge of high pressure crossed England on the 13th and was followed by a trough of low pressure which extended from east Scotland to the Scilly Isles on the morning of the 14th and moved slowly north-eastwards becoming an almost stationary area of low pressure over the North Sea on the 16th, which slowly filled up. Temperatures were about or just below average during this period: sunshine totals were very variable and were fairly good at some individual stations although Manchester and Huddersfield recorded no sunshine on the three days, 14th to 16th. A ridge of high pressure moved eastwards over the British Isles on the 17th and a wedge of high pressure crossed on the 18th. Rainfall was very slight generally on these two days but sunshine totals were poor and there was fog at south-western coastal stations early on the 18th.

A depression centred over Iceland on the 19th deepened and a trough of low pressure extending from southern Norway to the Bristol Channel on the 20th moved very slowly eastwards. This was followed by a ridge of high pressure on the 21st and pressure remained high over England until the 24th. Temperatures were high during this period, sunshine totals were much better generally and there was very little rainfall, although there was fog at several stations on these days.

A complex low pressure area over the Atlantic to the west of Ireland on the 25th moved slowly eastwards and a series of secondary depressions moving north-eastwards along the west coasts caused heavy rain in the west and north. Rainfall was particularly heavy on the 29th : 4·37 inches were recorded at Garinish Island, Co. Cork, and many stations had over 2 inches in Ireland, and in the north and west of Great Britain rainfall was also very heavy. Extensive flooding occurred in the English Lake district as a result of the heavy falls on the 29th and 30th : Borrowdale in Cumberland had 5·60 inches on the 29th and 2·56 inches on the 30th, while at a few stations the rainfall of the 29th was the highest daily total in records going back more than 20 years. The deep depression which had become almost stationary north of Ireland on the 29th subsequently decreased in intensity and gave way to a belt of high pressure which stretched across England on the 31st connecting anticyclones over the Baltic and mid-Atlantic. Temperatures rose considerably on the 30th and 31st and a maximum of 85° F. recorded at Tunbridge Wells and Southend on the 31st was the highest recorded this year to date. There was fog at many stations on the 30th and 31st.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway	126	−19	**Chester**	142	−31
Aberdeen	140	−12	**Ross-on-Wye**	151	−41
Dublin	99	−71	**Falmouth**	142	−75
Birr Castle	102	−47	**Gorleston**	179	−32
Valentia	106	−51	**Kew**	147	−47

Kew temperature, mean, 62·3°F : diff. from average −2·2°F.

Miscellaneous notes on weather abroad from various sources.

Heavy rain in the Carpathian foothills and snow in the High Tatras caused floods in many parts of Galicia in the early part of the month. Villages were evacuated and several lives lost, but little damage was done to the grain harvest, which promises to be above the average of the last five years. A hailstorm which swept over part of the Dauphiné on the 25th caused much damage to crops and shattered many panes of glass. A violent thunderstorm was reported from Torsac, Charante, on the 26th. A wave of heat spread over France on the 30th–31st, temperatures of more than 90° F. being recorded in many places. (*The Times*, July 13th–August 2nd.)

Serious flooding in Kobe was reported on the 5th after two days of abnormally heavy rainfall. Hundreds of people were drowned, many houses demolished and business completely disorganised. The damage is officially estimated at nearly £6,000,000. Osaka and Kyoto Prefectures also experienced extensive floods. The early onset of the monsoon caused the abandonment of the attempt to climb Mt. Masherbrum, in the Karakorum, and delay in the German expedition to Nanga Parbut on the 8th. (*The Times*, July 6th–26th.)

General rain fell in New South Wales during the latter part of the month, improving the pastoral outlook. The drought in the south-west and west areas of Australia was also broken. (*The Times*, July 30th.)

Daily Readings at Kew Observatory, July, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain	Sun	REMARKS
			Min.	Max.				
1	1008·9	E 2	48	67	51	0·01	6·4	t 14h., pr$_0$ 15h. & 16h.
2	13·6	W 2	48	67	49	0·04	6·7	tpR 15h., t 18h.
3	17·4	WSW 2	49	68	60	Trace	3·5	pr$_0$ 18h.
4	06·3	SSW 4	53	67	56	Trace	6·6	tpr$_0$ 14h., pr$_0$ 15h.
5	02·1	NW 2	48	63	74	0·14	6·7	pR 9h., tpr$_0$ 9h.–13h.
6	13·1	SSW 3	49	67	52	Trace	5·7	pr$_0$ 1h. & 13h.–15h.
7	06·6	ESE 4	54	75	61	0·05	1·6	pr 11h.–15h., t 17h.
8	03·1	SSW 5	55	63	68	0·26	0·5	ir$_0$–r 7h.–16h., pR 19h.
9	17·2	WSW 3	54	64	58	Trace	4·0	pr$_0$ 10h., 14h. & 17h.
10	19·4	SSW 4	52	64	77	Trace	1·4	pr$_0$ 10h. & 24h.
11	09·5	SW 4	59	71	65	—	4·5	
12	08·7	W 2	56	65	63	Trace	0·3	pr$_0$ 11h.
13	17·8	NNW 1	54	74	45	—	9·5	
14	16·4	SW 3	56	67	64	—	0·0	
15	14·6	W 2	58	65	81	0·23	0·1	r 12h., r–r$_0$ 17h.–20h.
16	19·5	WNW 3	52	63	72	Trace	1·8	pr$_0$ 13h., 15h. & 18h.
17	23·2	WSW 3	53	70	49	Trace	8·4	pr$_0$ 18h.
18	22·4	W 3	58	68	70	Trace	0·9	ir$_0$ 14h.–15h.
19	20·7	SW 2	56	72	64	—	8·6	m till 8h.
20	18·1	WSW 2	56	76	65	—	7·1	
21	18·6	N 1	61	75	52	—	3·7	
22	16·8	SE 2	60	72	65	—	0·0	
23	14·5	ENE 2	56	74	52	—	2·6	
24	12·5	S 2	55	78	57	—	5·2	w early.
25	13·0	SSW 3	56	74	54	0·01	6·0	r–r$_0$ 20h.–21h.
26	11·7	WSW 3	59	72	42	—	5·5	
27	16·2	S 5	52	74	41	0·28	8·9	r$_0$–r 19h.–23h.
28	16·1	WSW 3	53	69	55	—	8·2	
29	17·6	SSW 4	53	72	54	—	3·7	w early.
30	16·8	SSW 4	56	74	58	—	13·6	
31	1021·2	SSW 2	63	82	64	—	4·9	
*	1014·6	—	55	70	59	1·02	4·7	* Means or Totals.

General Rainfall for July, 1938

England and Wales	115	per cent of the average 1881–1915.
Scotland	143	
Ireland	163	
British Isles ...	132	

Rainfall : July, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
Lond .	Camden Square..........	1·17	49	*Leics* .	Thornton Reservoir ...	3·26	131
Sur .	Reigate, Wray Pk. Rd..	2·09	93	,, .	Belvoir Castle............	2·71	112
Kent .	Tenterden, Ashenden...	1·76	84	*Rut* .	Ridlington	2·42	96
,, .	Folkestone, Boro. San.	2.18	...	*Lincs* .	Boston, Skirbeck.........	2·19	99
,, .	Margate, Cliftonville....	2·16	109	,, .	Cranwell Aerodrome...	2·83	121
,, .	Eden'bdg., Falconhurst	1·68	73	,, .	Skegness, Marine Gdns.	2·34	107
Sus .	Compton, Compton Ho.	2·48	88	,, .	Louth, Westgate.........	2·43	97
,, .	Patching Farm..........	1·72	72	,, .	Brigg, Wrawby St.......	3·33	...
,, .	Eastbourne, Wil. Sq....	1·84	84	*Notts* .	Mansfield, Carr Bank...	3·95	151
Hants.	Ventnor, Roy.Nat.Hos.	1·54	76	*Derby*.	Derby, The Arboretum	4.28	173
,, .	Southampton,East Park	2·42	106	,, .	Buxton, Terrace Slopes	5·57	142
,, .	Ovington Rectory.......	4·01	155	*Ches* .	Bidston Obsy.............	2·71	105
,, .	Sherborne St. John......	1·73	78	*Lancs*.	Manchester, Whit. Pk.	4.48	136
Herts .	Royston, Therfield Rec.	1·45	58	,, .	Stonyhurst College......	4·67	121
Bucks.	Slough, Upton............	1·13	59	,, .	Southport, Bedford Pk.	2·90	101
Oxf .	Oxford, Radcliffe.........	1·18	50	,, .	Ulverston, Poaka Beck	7.04	155
N'hant	Wellingboro, Swanspool	1·65	72	,, .	Lancaster, Greg Obsy.	4·39	125
,, .	Oundle	1·48	...	,, .	Blackpool	3·61	124
Beds .	Woburn, Exptl. Farm...	1·51	68	*Yorks*.	Wath-upon-Dearne......	2·95	118
Cam .	Cambridge, Bot. Gdns.	1·33	62	,, .	Wakefield,Clarence Pk.	3·15	124
,, .	March.......................	1·29	54	,, .	Oughtershaw Hall.......	6·62	...
Essex .	Chelmsford,County Gdns	1·00	47	,, .	Wetherby, Ribston H..	3·98	159
,, .	Lexden Hill House......	1·22	...	,, .	Hull, Pearson Park......	3·75	160
Suff .	Haughley House.........	1·49	...	,, .	Holme-on-Spalding......	3·28	127
,, .	Rendlesham Hall........	1·91	82	,, .	Felixkirk, Mt. St. John.	2·84	104
,, .	Lowestoft Sec. School...	1·57	69	,, .	York, Museum Gdns....	2·33	92
,, .	Bury St. Ed., WestleyH.	1·62	65	,, .	Pickering, Houndgate...	2·81	104
Norf. .	Wells, Holkham Hall...	1·36	59	,, .	Scarborough..............	2·19	90
Wilts .	Porton, W.D. Exp'l. Stn	2.25	114	,, .	Middlesbrough...........	2.85	111
,, .	Bishops Cannings........	2·45	98	,, .	Baldersdale, Hury Res.	3·43	107
Dor .	Weymouth, Westham.	1·91	106	*Durh* .	Ushaw College...........	2·51	90
,, .	Beaminster, East St....	3·85	148	*Nor* .	Newcastle, Leazes Pk...	2·29	89
,, .	Shaftesbury,Abbey Ho.	2·33	91	,, .	Bellingham, Highgreen	3·22	98
Devon.	Plymouth, The Hoe....	3·35	121	,, .	Lilburn Tower Gdns....	3·70	150
,, .	Holne, Church Pk. Cott.	5·24	149	*Cumb*.	Carlisle, Scaleby Hall...	5·54	169
,, .	Teignmouth, Den Gdns.	3·06	131	,, .	Borrowdale, Seathwaite	21·00	270
,, .	Cullompton	2·91	108	,, .	Thirlmere, Dale Head H.	11·31	194
,, .	Sidmouth, U.D.C........	3·48	...	,, .	Keswick, High Hill......	6·74	176
,, .	Barnstaple, N. Dev.Ath	2·86	106	,, .	Ravenglass, The Grove	6·16	164
,, .	Dartm'r,Cranmere Pool	6·20	...	*West* .	Appleby, Castle Bank...	4·70	149
,, .	Okehampton, Uplands.	4·32	133	*Mon* .	Abergavenny, Larchf'd	3·29	132
Corn .	Redruth, Trewirgie......	4·60	151	*Glam* .	Ystalyfera, Wern Ho....	6·53	142
,, .	Penzance, Morrab Gdns.	3·94	145	,, .	Treherbert, Tynywaun.	7·77	...
,, .	St. Austell, Trevarna...	3·93	117	,, .	Cardiff, Penylan..........	3·63	118
Soms .	Chewton Mendip.........	3·58	103	*Carm* .	Carmarthen,M. & P. Sch.	...	...
,, .	Long Ashton............	3·94	139	*Pemb* .	Pembroke,Stackpole Ct.	...	...
,, .	Street, Millfield..........	3·45	141	*Card* .	Aberystwyth	5·76	...
Glos .	Blockley	2·69	...	*Rad* .	BirmW.W.Tyrmynydd	5·83	142
,, .	Cirencester, Gwynfa....	2·54	98	*Mont* .	Newtown, Penarth Weir	...	...
Here .	Ross-on-Wye.............	2·28	100	,,	Lake Vyrnwy	5·15	150
Salop.	Church Stretton.........	2·40	98	*Flint* .	Sealand Aerodrome......	2·61	114
,, .	Shifnal, Hatton Grange	2·94	130	*Mer* .	Blaenau Festiniog	11·32	145
,, .	Cheswardine Hall........	2·83	104	,, .	Dolgelley, Bontddu......	7·87	185
Worc .	Malvern, Free Library...	3·20	140	*Carn* .	Llandudno	2·64	118
,, .	Ombersley, Holt Lock.	2·94	137	,, .	Snowdon, L. Llydaw 9..	22·50	...
War .	Alcester, Ragley Hall...	2·91	122	*Ang* .	Holyhead, Salt Island...	4·11	157
,, .	Birminghm, Edgbaston	3·00	129	,, .	Lligwy	5·35	...

Erratum : Llandudno, June, *for* 3·03/150 *read* 3·03/159

Rainfall : July, 1938 : Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem....	5·27	172	*R&C* .	Achnashellach............	6·42	125
Guern.	St.Peter P't.Grange Rd.	2.16	107	„ .	Stornoway,C.GuardStn.	2·67	93
Wig .	Pt. William, Monreith.	5·23	186	*Suth* .	Lairg......................	4·66	149
„ .	New Luce School.........	5·97	176	„ .	Skerray Borgie...........	7·38	...
Kirk .	Dalry, Glendarroch......	5·88	164	„ .	Melvich....................	4·93	176
Dumf.	Dumfries, Crichton R.I.	...	...	„ .	Loch More, Achfary....	8·13	152
„ .	Eskdalemuir Obs........	8.87	216	*Caith* .	Wick.......................	3·46	132
Roxb .	Hawick, Wolfelee........	4.92	160	*Ork* .	Deerness	2·85	111
Peeb .	Stobo Castle.............	...	...	*Shet* .	Lerwick Observatory...	2·82	123
Berw .	Marchmont House......	3·43	112	*Cork* .	Cork, University Coll...	3·97	147
E.Lot.	North Berwick Res.....	3·04	118	„ .	Roches Point, C.G. Stn.	4·78	166
Midl .	Edinburgh, Blackfd. H.	2·43	86	„ .	Mallow, Longueville....	3·52	141
Lan .	Auchtyfardle	4·23	...	*Kerry*.	Valentia Observatory...	5·89	156
Ayr .	Kilmarnock, Kay Park	4·78	...	„ .	Gearhameen..............	10·60	184
„ .	Girvan, Pinmore.........	5·79	159	„ .	Bally McElligott Rec...	5·87	...
„ .	Glen Afton, Ayr San....	6·34	151	„ .	Darrynane Abbey.......	5·86	154
Renf .	Glasgow, Queen's Park	4·64	159	*Wat* .	Waterford, Gortmore...	5·78	182
„ .	Greenock, Prospect H..	4·57	124	*Tip* .	Nenagh, Castle Lough.	6.05	193
Bute .	Rothesay, Ardencraig...	4·98	126	„ .	Cashel, Ballinamona....	5·02	176
„ .	Dougarie Lodge..........	4·74	150	*Lim* .	Foynes, Coolnanes......	4·57	148
Arg .	Loch Sunart, G'dale....	5·86	126	*Clare* .	Inagh, Mount Callan....	8·86	...
„ .	Ardgour House..........	8·80	...	*Wexf* .	Gorey, Courtown Ho...	5·76	196
„ .	Glen Etive................	...	...	*Wick* .	Rathnew, Clonmannon.	5·48	...
„ .	Oban.......................	5.80	...	*Carl* .	Bagnalstown,Fenagh H.	5·65	179
„ .	Poltalloch.................	5·39	131	„ .	Hacketstown Rectory...	5·85	170
„ .	Inveraray Castle.........	8·64	174	*Leix* .	Blandsfort House.......	6·06	194
„ .	Islay, Eallabus...........	4·23	124	*Offaly*.	Birr Castle...............	6·71	227
„ .	Mull, Benmore...........	...	...	*Kild* .	Straffan House...........	5·51	195
„ .	Tiree.......................	3·81	105	*Dublin*	Dublin, Phoenix Park..	3.89	145
Kinr .	Loch Leven Sluice.......	3.71	129	*Meath*.	Kells, Headfort..........	5·37	169
Fife .	Leuchars Aerodrome...	3·26	125	*W.M* .	Moate, Coolatore.........	5·85	...
Perth .	Loch Dhu..................	5.95	123	„ .	Mullingar, Belvedere...	...	...
„ .	Crieff, Strathearn Hyd.	3·77	127	*Long* .	Castle Forbes Gdns......	5·65	181
„ .	Blair Castle Gardens....	4·73	185	*Gal* .	Galway, Grammar Sch.	4·68	146
Angus.	Kettins School...........	4·01	155	„ .	Ballynahinch Castle....	8·03	194
„ .	Pearsie House............	5·55	...	„ .	Ahascragh, Clonbrock.	5·78	166
„ .	Montrose, Sunnyside...	3·54	135	*Rosc* .	Strokestown, C'node.....	5·03	180
Aber .	Balmoral Castle Gdns..	4·72	185	*Mayo*.	Blacksod Point..........	2·57	82
„ .	Logie Coldstone Sch....	...	...	„ .	Mallaranny	5·20	...
„ .	Aberdeen Observatory.	4·62	164	„ .	Westport House.........	2·98	96
„ .	New Deer School House	...	...	„ .	Delphi Lodge............	9·81	148
Moray	Gordon Castle............	4·60	144	*Sligo* .	Markree Castle..........	3·71	107
„ .	Grantown-on-Spey	4.00	130	*Cavan*.	Crossdoney, Kevit Cas..	5·52	...
Nairn.	Nairn	4.55	170	*Ferm* .	Crom Castle..............	7·08	203
Inv's .	Ben Alder Lodge.........	4·10	...	*Arm* .	Armagh Obsy............	4.78	165
„ .	Kingussie, The Birches.	3·76	...	*Down*.	Fofanny Reservoir......	7·00	...
„ .	Loch Ness, Foyers	4·54	150	„ .	Seaforde	5·82	182
„ .	Inverness, Culduthel R.	4.36	168	„ .	Donaghadee, C. G. Stn.	3·87	139
„ .	Loch Quoich, Loan......	7·73	...	*Antr* .	Belfast,Queen's Univ....	4·38	147
„ .	Glenquoich................	8·13	127	„ .	Aldergrove Aerodrome.	4·29	153
„ .	Arisaig House............	6·86	138	„ .	Ballymena, Harryville.	4·62	135
„ .	Glenleven, Corrour......	5·29	128	*Lon* .	Garvagh, Moneydig....	5·22	...
„ .	Fort William, Glasdrum	8.53	...	„ .	Londonderry, Creggan.	5·31	145
„ .	Skye, Dunvegan.........	4·83	...	*Tyr* .	Omagh, Edenfel.........	5·08	149
„ .	Barra, Skallary..........	3·58	...	*Don* .	Malin Head..............	3·89	114
R&C.	Tain, Ardlarach.........	6·59	223	„ .	Dunfanaghy..............	3·73	127
„ .	Ullapool	4·80	151	„	Dunkineely...............	3·67	...

Erratum : Fort William, Glasdrum, June *for* 8·74/*read* 9·24

Climatological Table for the British Empire, February, 1938

STATIONS	PRESSURE		TEMPERATURE							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal	Wet Bulb			Am'nt.	Diff. from Normal	Days	Hours per day	Percentage of possible
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1025·2	+ 9·2	55	28	46·2	37·2	41·7	+ 1·0	37·4	84	7·4	0·31	– 1·23	7	2·5	25
Gibraltar	1022·3	+ 2·3	63	39	56·7	50·2	53·5	– 2·3	48·4	74	6·3	0·69	...	6	...	...
Malta	1018·7	+ 2·6	63	42	56·0	48·1	52·1	– 3·2	47·1	72	6·3	6·37	+ 4·17	10	5·9	55
St. Helena	1015·3	– 0·6	72	59	69·2	61·0	65·1	– 0·1	61·9	92	8·6	2·90	+ 0·22	18	...	...
Freetown, Sierra Leone	1010·5	+ 1·4	91	73	88·1	74·9	81·5	...	75·6	77	3·4	0·00	– 0·30	0	...	...
Lagos, Nigeria	1009·1	– 0·6	92	73	89·5	76·6	83·1	+ 0·6	77·4	89	6·1	3·08	+ 1·18	4	6·7	56
Kaduna, Nigeria	1012·2	...	99	55	93·3	60·3	76·8	– 0·1	55·6	42	2·1	0·00	– 0·02	0	9·7	82
Zomba, Nyasaland	1008·9	+ 0·8	88	59	80·5	64·0	72·3	+ 0·3	70·7	86	5·9	10·30	– 0·35	8	...	...
Salisbury, Rhodesia	1010·3	+ 0·1	87	51	79·8	58·7	69·3	+ 0·5	62·0	72	6·4	1·84	...	5	8·7	69
Cape Town	1013·9	+ 0·5	88	54	79·0	60·4	69·7	– 0·6	61·2	73	4·0	0·25	– 0·33	4	...	...
Johannesburg	1011·3	0·0	81	45	75·5	54·8	65·1	– 0·5	57·1	71	5·8	3·29	– 1·93	10	7·9	61
Mauritius	1009·3	– 1·5	90	69	86·4	73·4	79·9	+ 0·6	75·4	75	5·6	8·79	+ 1·28	15	8·7	67
Calcutta, Alipore Obsy.	1013·4	+ 0·1	89	50	81·8	58·2	70·0	– 1·2	58·8	78	2·0	1·11	+ 0·12	3*	...	...
Bombay	1011·8	– 0·9	94	60	82·9	66·5	74·7	– 1·0	64·0	67	0·7	0·00	– 0·03	0*	...	...
Madras	1011·8	– 1·1	88	67	85·6	72·3	78·9	+ 1·2	73·4	80	5·5	0·54	+ 0·24	2*	...	...
Colombo, Ceylon	1010·5	– 0·3	90	69	86·2	73·9	80·1	– 0·3	76·2	79	5·8	5·97	+ 4·03	13	7·4	62
Singapore	1010·4	+ 0·2	94	72	88·3	75·1	81·7	+ 1·5	77·8	74	6·8	4·72	– 1·90	13	7·1	59
Hongkong	1017·6	– 1·0	78	47	63·3	55·7	59·5	+ 0·4	54·7	73	7·4	4·69	+ 2·86	11	3·7	33
Sandakan	1010·4	...	87	71	84·6	74·1	79·3	– 0·9	76·1	87	8·5	24·02	+ 13·05	13	...	...
Sydney, N.S.W.	1008·6	– 5·3	88	58	79·0	65·0	72·0	+ 0·7	65·2	63	4·8	3·56	– 0·64	8	7·9	59
Melbourne	1008·4	– 6·1	103	49	79·4	57·1	68·3	+ 0·7	59·9	57	6·0	1·87	+ 0·16	8	6·5	48
Adelaide	1009·8	– 4·5	107	53	81·8	61·8	71·8	– 2·2	61·4	49	6·5	2·45	+ 1·73	13	7·0	53
Perth, W. Australia	1011·4	– 1·6	99	50	83·0	61·4	72·2	– 1·9	61·1	48	3·5	0·13	– 0·32	1	11·1	84
Coolgardie	1012·5	+ 0·1	102	47	88·7	61·2	74·9	– 1·3	59·8	49	3·9	0·49	– 0·36	2	...	...
Brisbane	1008·4	– 4·1	97	63	86·9	70·6	78·7	+ 2·2	71·7	69	5·0	5·62	– 0·72	7	8·9	68
Hobart, Tasmania	1006·8	– 6·4	87	41	70·7	54·6	62·7	+ 0·4	56·5	67	6·1	4·26	+ 2·78	17	6·4	46
Wellington, N.Z.	1016·2	+ 0·4	79	54	71·1	59·5	65·3	+ 2·7	62·9	81	7·4	6·32	+ 3·18	12	5·9	43
Suva, Fiji	1006·6	– 1·2	91	72	87·6	76·1	81·9	+ 1·6	77·3	84	6·1	8·45	– 2·27	24	6·5	51
Apia, Samoa	1007·8	– 0·6	89	73	85·3	75·1	80·2	+ 1·2	76·5	80	6·5	13·35	– 1·94	23	5·1	41
Kingston, Jamaica	1015·9	+ 0·6	88	63	84·3	67·0	75·7	– 0·8	64·5	82	2·5	0·20	– 0·40	4	5·6	48
Grenada, W.I.	1011·3	– 2·2	89	71	87	73	80	+ 2·9	75	75	5	2·04	– 0·74	15	...	...
Toronto	1022·6	+ 4·6	51	– 4	33·9	20·5	27·2	+ 6·1	...	...	7·3	3·62	+ 1·24	14	3·0	29
Winnipeg	1025·4	+ 3·6	47	–33	14·3	–5·1	4·6	+ 4·5	...	...	4·6	1·72	+ 0·98	8	4·3	43
St. John, N.B.	1020·7	+ 6·8	40	– 4	27·5	11·1	19·3	– 0·6	15·5	79	6·0	3·60	– 0·30	15	4·0	38
Victoria, B.C.	1011·0	– 5·6	57	31	46·6	36·8	41·7	+ 1·2	39·3	86	7·9	1·81	– 1·45	15	3·3	32

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

(43235) Wt. 21/31 1125 8/38 Hw. G. 377/6.

SIR GEORGE C. SIMPSON, F.R.S.

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PRESENTATION
TO
SIR GEORGE SIMPSON
AND
LADY SIMPSON

The retirement of Sir George Simpson, K.C.B., C.B.E., D.Sc., F.R.S., on September 2nd after 18 years service as Director closed another chapter in the history of the Meteorological Office. The occasion was marked by a memorable ceremony in the library of the Office at South Kensington at which a presentation was made to Sir George and Lady Simpson from the staff of the Office.

Mr. R. G. K. Lempfert, Assistant Director, presided, and opened the proceedings by offering congratulations to Sir George on his 60th birthday. He proceeded, in a very interesting speech, to trace the early history of the Meteorological Office and included some recollections of Mr. G. C. Simpson, as he was then, when in 1905 he worked in the Office for a time as a voluntary assistant. He gave also an outline of Sir George Simpson's career and experience in various parts of the world and referred in particular to his important researches in geophysics. In speaking of the period subsequent to the appointment of Sir George as Director of the Office in 1920, Mr. Lempfert recalled the difficulties which had to be surmounted at that time when the Office was still in process of transfer to the Air Ministry and the many important developments which had since taken place, especially during the last few strenuous years. He asked Sir George to accept a silver tray, suitably inscribed, and an album containing the signatures of members of the staff at home and abroad, as a concrete expression of their regard and as a reminder of happy days spent in the Meteorological Office.

Lady Simpson was the recipient of a travelling watch in a leather case, which was presented on behalf of the staff by Miss D. G. Chambers, who referred to the many ways in which Lady Simpson had, during the whole of her husband's term of office, shown her interest in the Office and the staff. In a charming and witty speech Lady Simpson expressed her gratitude for the gift and particularly for the thoughts which had prompted it.

A further tribute to Sir George Simpson took the form of a handsome silver cup which the staff of the Meteorological Office presented to the Air Ministry Athletic Association, to be known as the Simpson Cup and awarded annually for the best individual performance in departmental sport and athletics. Mr. H. L. B. Tarrant acted as spokesman for the staff and asked Mr. Richards, Chairman of the Athletic Association, to accept the cup in commemoration of the deep interest which Sir George had always displayed in every kind of sport in the Office and the Air Ministry. In accepting the cup, Mr. Richards spoke in terms of warm appreciation of the valuable assistance which Sir George had rendered to the Athletic Association, particularly since 1925 as Vice-Chairman of the Executive Committee and later as Vice-President of the Association and as Treasurer of the Sports Committee. Mr. Richards regarded it as very appropriate that the name of Sir George should be perpetuated in that way and expressed the thanks of the Association to the staff of the Meteorological Office for presenting the cup.

Sir George Simpson said that it was difficult to express one's feelings on such an occasion. Of the gifts which had been made he appreciated most of all the album of signatures because it was a personal token and he had always laid great stress upon the personal relationship between the different grades in the Office. Next in order of his appreciation was the silver cup which had been presented to the Athletic Association. He had, indeed, always taken a keen interest in departmental sport and he hoped that one of the names to be inscribed upon the cup would be that of a member of the staff of the Office. Sir George recalled the many changes that had taken place since he became Director and, as a matter of personal pleasure, to the improvement which had been effected in the grading of the staff. He expressed warm thanks to all members of the staff for their help and support and mentioned specially the friendship and co-operation which had been given to him throughout by the Assistant Directors.

The Thunderstorms of August, 1938

The first twelve days of August provided a remarkable series of thunderstorms over practically the whole of the British Isles. Among the stations from which observations are published in the *Daily Weather Report,* only Blacksod Point and Lerwick escaped thunder in the period. Blacksod had heavy rains of thunderstorm origin, but Lerwick had no rain and 125 hours of sunshine in the twelve days. There was a period of 13 consecutive days of more or less widespread thunderstorms as recently as June 14th–26th, 1933,[1] but the recent storms were of a severer type, occurring in warmer and damper weather.

The 46 stations for which day and night observations are published on page 1 of the *Daily Weather Report* give a fairly good indication of the frequency of the storms. The following table gives the number of reports of thunder in the period, after entering up certain observations missing in the original issue, owing to telegraphic breakdowns caused by the storms.

August, 1938.	1h.–7h.	7h.–13h.	13h.–18h.	18h.–1h.	Total.
1	0	3	6	2	11
2	0	4	2	2	8
3	1	0	2	4	7
4	9	7	9	15	40
5	7	8	4	6	25
6	4	1	2	3	10
7	2	3	3	4	12
8	6	2	7	1	16
9	0	3	8	3	14
10	0	2	2	1	5
11	0	0	9	7	16
12	2	7	20	7	36
Total ...	31	40	74	55	200

It will be noted that there was a considerable number of night storms, and it was only on the 1st and after the 8th that the characteristic diurnal variation asserted itself. Up till the 8th the storms were mainly of frontal type. Fig. 1 shows the chart for 13h. on August 1st, the first day of thunder. The pressure distribution had changed greatly since July 30th, when there was a pronounced southwest current, with flooding in the Lake district. In the 48 hours ending at 7 h. on 1st pressure had risen by 26 mb. at Wick, and 35 mb. at a point about 400 miles west of Blacksod Point. This development originated in an ordinary wedge of high pressure. The storms on

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[1] W. A. L. Marshall, "The Thunderstorms of June, 1933", *London Quart. J.R. Met. Soc.*, 59, 1933, p. 416.

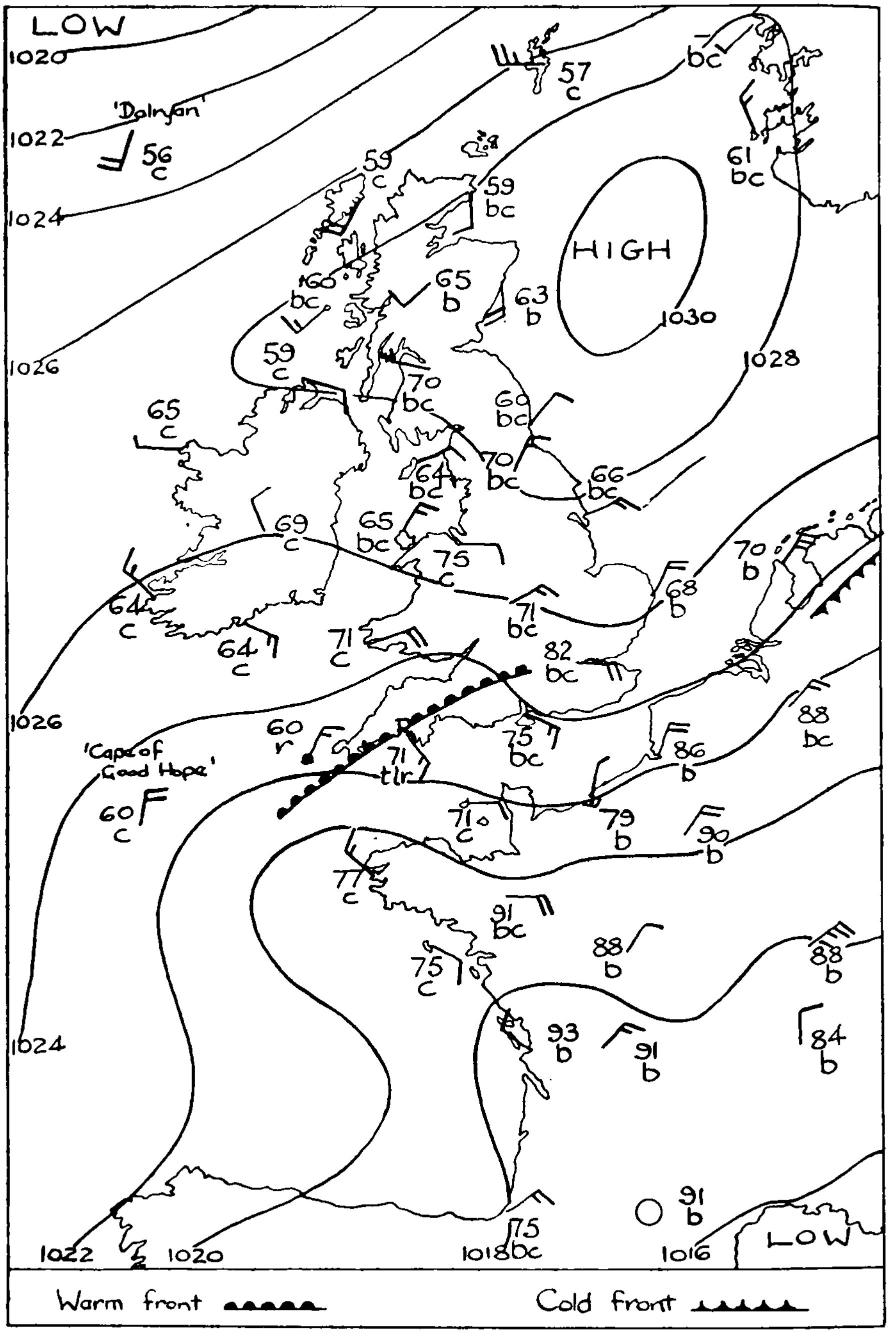
LOW
1020
'Dolnyan'
1022
56 c
1024
57 c
bc
59 c
59 bc
HIGH
61 bc
1026
60 bc
65 b
63 b
1030
1028
59 c
70 bc
65 c
60 bc
70 bc
64 bc
66 bc
69 c
65 bc
75 c
70 b
68 b
64 c
64 c
71 c
71 bc
82 bc
1026
60 r
'Cape of Good Hope'
71 tlr
75 bc
86 b
88 bc
60 c
71 c
79 b
90 b
77 c
91 bc
88 b
88 b
75 c
93 b
91 b
84 b
1024
91 b
1022
1020
1018
75 bc
1016
LOW
Warm front
Cold front

FIG. 1. 13H. 1ST AUGUST, 1938, MONDAY

the 1st were general and severe in southwest England, and moved northwest over Wales and Ireland during the next 24 hours. The warm front marked on the chart, which gave rise to the storms, was originally a long cold front of Atlantic origin, and was associated with the rains of the 29th and 30th ; but only a part of the original front was still active in our area on the 1st, when it moved back under the influence of the reversed pressure distribution. It gave no rain over most of southern England till the surface air had been warmed and thunderstorms broke out. The cold front shown on fig. 1 over north-west Germany was originally joined to it. The bulge in the isobars off Brittany was separate from the front, and was due to the spreading of low pressure from the western Mediterranean. This development continued and was accompanied by a series of thunderstorms which moved northwest from France across southwest England to Wales and Ireland. Their source was the very warm continental air, which had spread westward from southern Russia during the last week of July. Much of the moisture must have been evaporated from the land surface. Since the surface layers contain most heat, moisture evaporated into them is specially effective for thunderstorm formation. (The humidity question is discussed more fully below, in relation to the aerological data.) At Rennes, Brittany, the temperature at 13h. on the 3rd was 91° F., and the (coded) relative humidity between 40 per cent. and 49 per cent., giving a wet bulb reading between 74° F. and 77° F. There were severe storms on the 2nd (2·18 in. of rain at Tenby) and the 3rd (*e.g.*, Roches Point), but these were completely eclipsed by the tremendous outbreak of the 4th, which made a land-mark in the meteorological history of southwest England. This was a most exceptional storm, outstanding for severity, duration, and the area covered, which included the whole of southwest England and the Scilly Isles. Full details are not yet available, and in any case will be confined to the land area, but there seems no doubt that the area where a heavy thunderstorm was simultaneously in progress must have been remarkably large. The storm arrived about midnight on the 3rd–4th, and over a considerable area in Devon and east Cornwall it lasted for eleven hours with little intermission. The largest rainfall so far reported was 6·39 in. at Torquay, and the area with over 2 inches extended to the north coast of the peninsula at Tintagel, Ilfracombe and Bude. Much damage was done, and traffic on the main Great Western Railway line had to be suspended for some hours owing to the threat of the flooded Teign to the bridge at Newton Abbot. Numerous roads were flooded.

The chart for 13h. on the 4th (chosen to show up the temperature distribution) is reproduced in Fig. 2. When the gradient for easterly winds died away over France the cooler air over the Bay of Biscay had a chance to cut into the very warm air and form a cold front. On the evening of the 3rd there was an outbreak of thunderstorms all along the west coast of France. By next day the very warm air over Brittany had risen between the cooler easterly and southwesterly currents. This scissors action undoubtedly contributed greatly to the severity and size of the storm. The hilly nature of southwest

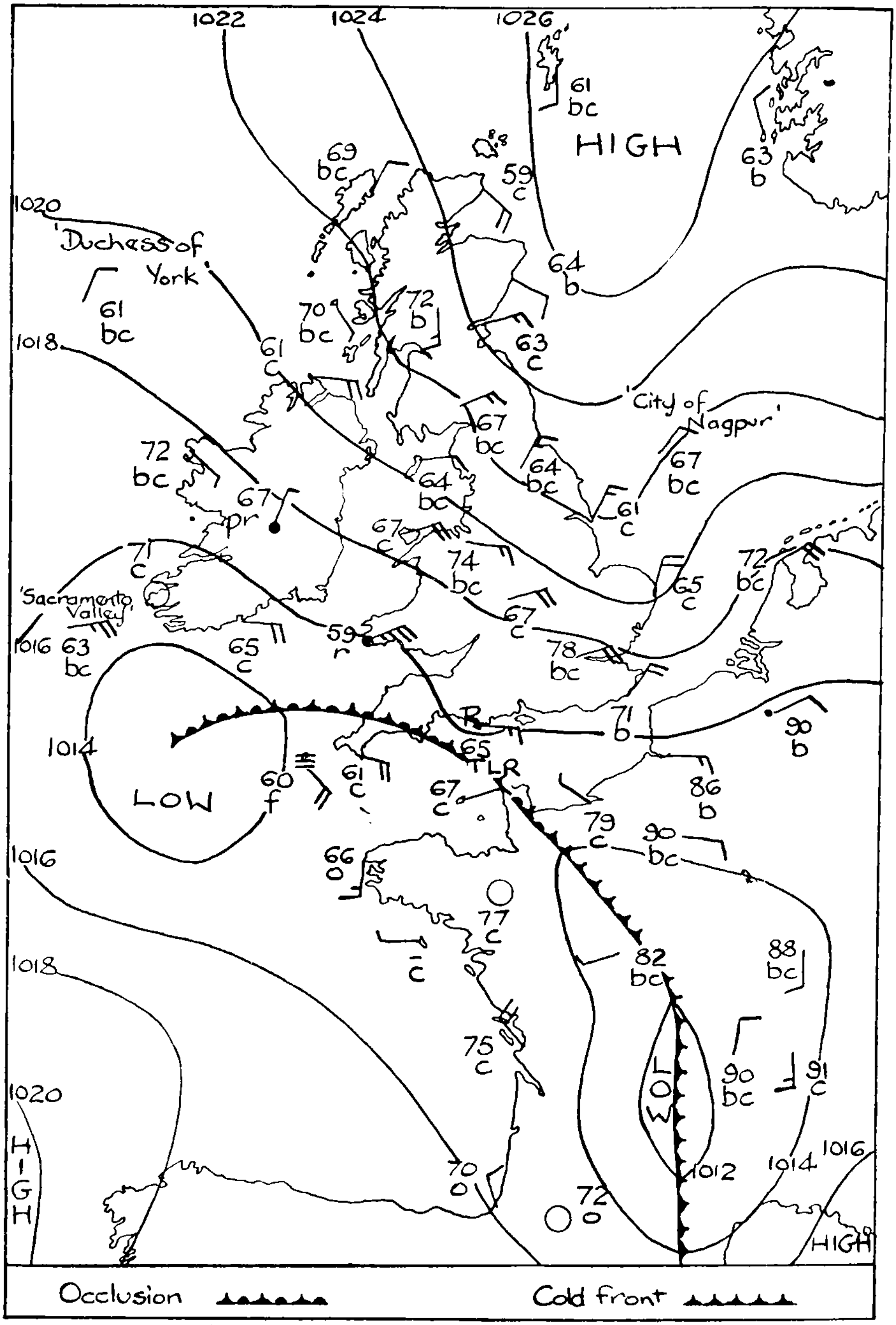
1022
1024
1026
HIGH
1020
'Duchess of York'
1018
'City of Nagpur'
'Sacramento Valley'
1016
1014
LOW
1016
1018
1020
HIGH
LOW
1012
1014
1016
HIGH
TLR
R
Occlusion
Cold front

Fig. 2. 13h. 4th August, 1938, Thursday

England probably also contributed. In the Channel area the front had the nature of an occlusion[1], but its exact position is doubtful, owing to the complexity which is characteristic of thundery fronts. The precipitation and barometric tendency indicated a position northeast of Guernsey, but the final veer of surface wind followed later. The storms were on the northeast side of the front. There was a general movement of the storm belt towards northeast, but the individual storms moved to a point between northwest and north. Before midnight the storms had spread to most of the midlands and one passed only a little to westward of London, evidently high up. Another series of violent storms broke out just ahead of the front over Paris and northeast France generally and moved northwards over Kent, giving a spectacular display of lightning during the night. Subsequently they moved north-northwest over northeast England to Scotland, drifting in the upper current right over the stable layers below.

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[1] No warm front is included as there was a gradual transition between the very warm air and the less warm air.

From the 6th onwards the thundery period entered a new phase. The complex shallow depression which had worked up slowly from off southern France was over the British Isles, with high pressure to northeast and southwest. The occlusion shown in Fig. 2. could be traced as a complex fluctuating line of wind discontinuity up to the 9th, and a high proportion of the thunderstorms formed along it. The continental current still prevailed in the north (with much fog on the northeast coast) but elsewhere there was little air movement near the ground, though up above there was still a southeast current, in which the storms drifted, up to and including those of August 11th. This implied colder air to the southwest, and this worked in slowly, though high up its movement was masked by the larger wind component parallel to the isotherms. Fig. 3 shows isopleths of upper air temperatures at Mildenhall, based on observations at about 6h. every day and also about noon except on the 6th and 7th. The

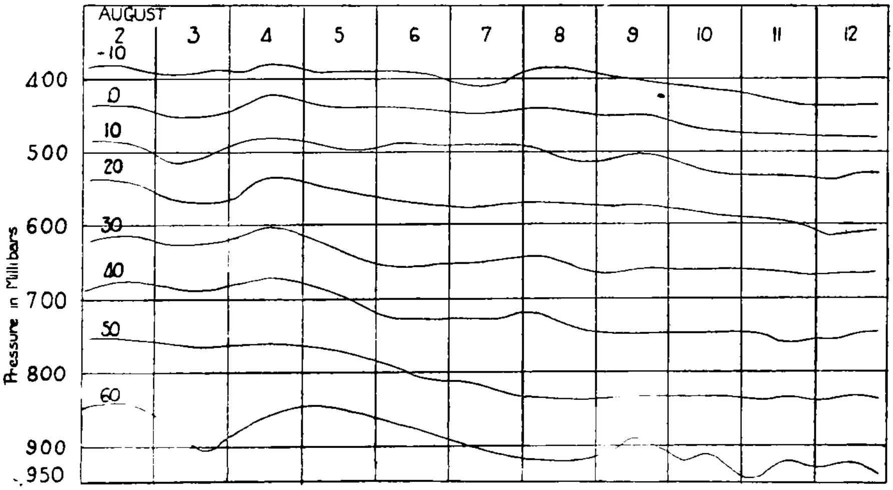

FIG. 3.—ISOPLETHS OF UPPER AIR TEMPERATURE AT MILDENHALL FOR EACH 10°F AUGUST 2ND TO 12TH, 1938.

pressure of 400 mb. corresponds to a height of about 25,000 feet, and 950 to about 2,000 feet. In the upper levels temperature was 5° to 10° F. above the August normal for most of the thundery period, but towards the end it dropped to normal, and diurnal convectional thunderstorms became more widespread and severe. On the 7th and 8th storms were mainly in Wales, northwest England and the midlands, but during the night of the 7th to 8th there was a thunderstorm with heavy rain in Kent, Ramsgate having 2·00 in. On the evening of the 11th there was a severe storm in south and west London, which caused flooding on the Kingston by-pass road. Previously London had curiously escaped the storms, though there had been welcome rains of thundery origin.

On the 12th there was much the worst outbreak since the 4th, affecting all Great Britain except the southwest. Cooler air was then spreading from west, but the storms in the south were mostly ahead of the cold front. Heavy hail fell locally, and at Wold Newton, near Bridlington, lay deep on the ground and lasted till next day. Violent thunder and lightning occurred locally over a wide area, but the regions of extreme severity were much smaller than on the 4th. Among the populous regions severely affected were Manchester, Sheffield and north London. The storm in the north London area developed very quickly, and the worst thunder and lightning was in the early stage, about 12h. G.M.T. Later in the afternoon the storm became general over London and extended far to the northwest, north and northeast, but though it was vigorous locally it was not of extreme violence.

The later storms were relatively straightforward, but the earlier ones are worth some further discussion, as they illustrate a type which is of extreme violence when once formed, but is difficult to predict. The associated front is not always clearly defined, and there is often fine weather near the storms, with dry air aloft. For example, at Duxford about noon on June 19th, 1936, relative humidity was below 40 per cent. from 2,000 to 5,000 feet and about 60 per cent. from 6,000 to 10,000 ft., while there was a severe storm over south and west London about 50 miles away. The Mildenhall observations on August 4th showed dry air aloft and nothing approaching " latent instability "[1], but the lapse-rate from 850 to 500 mb. (about 5,000 to 19,000 feet) was in excess of the saturated adiabatic, and only moisture was needed to cause instability. The dryness aloft continued on the 5th, when the thunderstorms were to northwards. The continental observations also showed no latent instability in the upper air, though evening thunderstorms formed in some cases quite near, but it was easy to deduce that the surface air in the afternoon must have had marked latent instability and often actual instability. The conceptions of " wet bulb potential temperature "[1] and of " latent instability " are of undoubted value in forecasting thunderstorms, but some additional terms would facilitate descriptions of possible thunderstorm conditions. One is a term indicating the existence of a lapse rate exceeding the saturated adiabatic. The other is a ready method of labelling the dry bulb temperature in terms of saturated adiabatic lines, which are numbered on the standard tephigram in terms of " wet bulb potential temperature ". At high levels it is the dry bulb and not the wet bulb readings which are important, since these layers constitute the environment of rising air. Over an area including Aldergrove, Mildenhall, Germany, Holland and north France the dry bulb temperatures at about 600 to 500 mbs. (14,500 to 19,000 feet) on August 4th and 5th were on the 64° F. to 68° F. saturated adiabatic lines on the tephigram. The temperature was fairly uniform at those levels in the area, and only air with a wet bulb potential temperature exceeding 68° F. would have possessed buoyancy all over the area after ascent to the heights mentioned. The available observations showed that only the air on or very near the surface on the Continent had a wet bulb potential temperature even as high as 64° F., but that at 13h. various places at ground level had wet bulb readings of about 75° F.

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[1] C. W. B. Normand, " On Instability from Water Vapour." *London Quart. J.R. met., Soc.* 64, 1938, p. 47.

There were some severe thunderstorms on the Continent, almost all associated with fronts. The central European storms on the evenings and nights of the 2nd and 3rd were associated with colder air spreading slowly from north. (According to Press reports, 26 people were killed by lightning in Poland.) The storms in northeast France later on the 4th broke out ahead of the front, but there was doubtless convergence. It is easy to see that convergence piles up the surface air and so supplies the moisture, but it is not clear why thunderstorms should travel far from the source of warm damp surface air, often well ahead of the front (*e.g.*, the storms over northern England on the 5th), unless there is a really damp layer aloft from which continuous supplies of moisture are available. Further observations are needed on this point, especially evening observations. The humidity mixing ratio[2] practically always decreases upwards, but vigorous mixing, associated with dry air convection in the lowest few thousand feet, must reduce the rate of decrease with height.

The local variations of humidity are the chief difficulty in forecasting thunder. Local variations of upper air temperature are limited by statical and dynamical considerations, but there is no such restriction on humidity variations. It is also obvious that large scale convection causes more horizontal variation of humidity than of temperature.

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[1] See e.g. D. Brunt, " Dynamical and Physical Meteorology " (Cambridge Univ. Press, 1934), p. 82.

[2] Weight of water vapour per unit mass of dry air.

As already mentioned, the upper current carrying the thunderstorms was southeasterly, occasionally veering temporarily to south, till the 11th. Up to the 5th the cirrus motion was southwest, but the veer was evidently right above the important layers. In a quasi-geostrophic wind system a wind veering with increased height involves advection of warmer air, but this only helps thunderstorm development when the layer of maximum temperature increase is low enough. If this layer is high up the effect, if any, is negative. In spite of the wind veer high up, the big storms of the 4th obviously penetrated to great heights, and great quantities of cirrostratus and altostratus streamed away at high levels. After August 6th, the southeast upper current extended to cirrus levels.

Really spectacular night storms are always preceded by great heat at no great distance. As a rule the air is maritime tropical in origin and is heated for a few days over land. In some cases prolonged continued heating over the land seems to be the cause of the great heat. In the case under discussion it is impossible from the information at present available to trace the air back previous to the appearance of very high temperatures over south Russia on July 23rd, with an east wind. Since thunderstorm frequency is high in eastern Europe, it is evident that the moisture is often there, and its occasional westward transport presents no difficulty.

C. K. M. D.

The Thunderstorm Rains of August 1st–12th, 1938

During the first twelve days of August a remarkable series of widespread thunderstorms, giving intense rains locally, was experienced. Of these the most outstanding was that recorded at Torquay during the morning of the 4th, when as much as 5·72 in. fell in five hours and ten minutes, between 6h. 50m. and 12h., of which 4·25 in. occurred in 108 minutes from 7h. 12m. to 9 h. At Paignton the intense rain was of shorter duration, 2·71 in. occurring in 45 minutes from 5h. 56m. to 6h. 41m.

At Tenby, in Pembrokeshire, 2·15 in. was recorded on the 2nd, the bulk of which fell during a thunderstorm between 14h. and 17h. 35m.

The heavy rain of the morning of the 4th gave totals exceeding one inch for the rainfall days, 3rd and 4th, over most of Cornwall, Devon and west Somersetshire. There was more than two inches over an area stretching from Bodmin to Seaton and including Dartmoor. More than four inches occurred from Torquay and Paignton to Moretonhampstead and Two Bridges. The entries for Torquay (Abbey Gardens) were 5·61 in. and ·78 in., a total of 6·39 in. To the west the totals were smaller, 3·97 in. being recorded at Ipplepen Vicarage. Further north-west in the neighbourhood of Hedgebarton, Ilsington and Ashburton the totals increased, the daily entries being at Hedgebarton 5·86 in. and ·59 in., Ilsington 5·35 in. and ·65 in.

and Ashburton 3·79 in. and 1·28 in. respectively. The distribution of the heavy rain has some resemblance to that which prevailed on July 17th, 1926 and on August 15th, 1905, although in these cases the areas of heavy rain were further east and the totals not nearly so large as those for August 3rd to 4th, 1908.

At Torquay, Mr. Bellinger reports that there was distant thunder at midnight ; louder thunder at 4h. ; heavy rain and hail 5h. 5m. to 5h. 15m. ; at 6h. 17m. rain recommenced ; from 6h. 50m. to 12h. the thunderstorm grew in intensity ; two types of clouds were observed, one coming from the south-east and the other, a lower type of nimbostratus, from the north-east ; heavy rain (·44 in.) fell during the period 12h. 30m. to 14h. The observer at St. Marychurch reports that the hailstones were the size of large lumps of sugar and formed about four inches of what looked like snow on the ground. At Hedgebarton, 15 miles to the north-west of Torquay, Mr. W. K. Kitson noted that the rain did not begin until about 4h. 15m. and by 8h. as much as 5·86 in. was recorded. Rain ceased at about 10h. 30m. but the maximum intensity was from 4h. 30m. to 8h. Very large hailstones occurred, but the hail was of short duration. For four hours the lightning appeared to be continuous. At Ilsington, Mr. J. F. Caley measured 5·35 in. of rain and hail from 4h. 30m. to 9h. 45m. Mr. Caldwell Harpur writing from Newlyn, to the south of Penzance, comments on the numerous lightning flashes " about 6,000 flashes of sheet lightning and six flashes like red bars from cloud to sea without any apparent thunder ". At Dunster, in north-west Somersetshire, the total rain amounted to 1·54 in. of which ·75 in. fell in 20 minutes.

Thunderstorms occurred in many parts of England and Wales on the 5th and intense falls were reported from parts of Lincolnshire and Yorkshire, E.R. At Horncastle ·96 in. fell in 50 minutes between 8h. 10m. and 9h. and at East Kirkby Manor, 7 miles to the south-east of Horncastle, 2·22 in. in 75 minutes between 8h. and 9h. 15m. At Bridlington, thunderstorms occurred at intervals during the day and in one storm three-quarters of an inch fell in an hour. It was on this day that some four hours from high water the sea receded suddenly for about 15 ft., leaving vessels high and dry, only to return with renewed force and refloat other craft further up the harbour.

The most intense rains for the 6th occurred at stations in Essex. Mr. E. F. Duggan at Holmwood House School, Lexden, reports that 2·25 in. occurred between 16h. 30m. and 17h. 30m., when the screen temperature fell from 83° F. to 65° F. At Corringham, 10 miles west of Southend, Mr. H. Mousley reports that 1·57 in. occurred in 57 minutes from 18h. 3m. to 19h. There was also heavy rain and considerable flooding in the neighbourhood of Liverpool in the early morning of the 6th.

At Fairford (Draycott), in Gloucestershire, 1·78 in. was recorded between 13h. and 16h. on the 7th during heavy rain accompanied by little thunder and lightning. The total for the day was 2·28 in. Falls of 1·68 in. and 1·64 in. were recorded for the 7th at Sudbury, Middlesex and Pyrton Manor near Watlington in Oxfordshire respectively. The 8th gave heavy thunderstorm rains accompanied by local flooding in Lancashire. The daily amount at Cathedine Rectory in Breconshire was 3·65 in.

As much as 2·40 in. was reported at Wath-upon-Dearne, near Rotherham, for the 9th, while intense falls were recorded at widely distributed stations, e.g., 1·44 in. in 45 minutes at Bishops Cannings; ·84 in. in 45 minutes at Ketton Cottage, Rutlandshire; ·53 in. in 12 minutes at Wellingborough and ·50 in. in 15 minutes at Birmingham. At Wallasey the total for the day was 2·75 in., of which 1·80 in. fell in 105 minutes from 14h. 25m. to 16h. 10m. and ·75 in. from 18h. 10m. to 18h. 50m.

On the 10th 1·13 in. fell in 48 minutes at Blandford (Bryanston Gardens) Dorsetshire. Intense thunderstorm rains occurred on the 11th at Edenbridge, in Kent, 1·21 in. occurring from 16h. to 16h. 45m. At Wembley, Mr. J. Monger measured 2·25 in. for the period 17h. to 18h. 30m. Some of the roads became rivers so that the carburettors of cars were flooded and trolley-buses stranded. Thunderstorms of unusual intensity, with precipitation running up to over five inches, occurred also in south-west Scotland. Flooding resulted quickly in wash-outs at two points on the railway near Strathaven, Lanarkshire, and caused the derailment of a passenger train. On the 12th, Edenbridge also recorded a fall of 2·26 in. from 16h. 15m. to 18h. 30m. At Blisworth, Northamptonshire, Mr. A. Westley recorded ·81 in. from 14h. 55m. to 15h. 15m., ·47 in. from 17h. 20m. to 17h. 50m. and ·58 in. from 18h. 30m. to 18h. 50m., a total of 2·30 in. in 5 hours. At Peterborough, 1·18 in. was recorded in 20 minutes when hail also occurred. Intense rains also occurred in Lancashire; at Chatburn School, to the north-west of Pendle Hill, 1·15 in. fell in 45 minutes. At Wold Newton, near Bridlington, there was 2 ft. of hail, so that roads were blocked and cars had to be dug out.

J. G.

Note on Experiments with No-Lift Balloons at Leuchars, Fife

S. T. A. Mirrlees, M.A.

Various expedients have been tried to get a sort of "Lagrangian" investigation of wind flow, varying from the simple one, applicable near the ground, of watching the movements of the winged seeds of the dandelion or thistle, to the much more complicated one, applicable to higher levels, of following the movements of a series of smoke puffs by cine-cameras. The "no-lift" balloon offers a compromise in that it can be used at moderate heights and does not involve very elaborate apparatus or several observers; it is, as the name indicates, a pilot balloon inflated with hydrogen so that it floats when carrying the usual tail system without rising or falling, so long as the air has no vertical component of motion. The balancing process has usually to be finished inside a building, conditions out-doors seldom being calm enough. When the balloon has been satisfactorily balanced (the final stages of the process being done by adding ballast of small wire paper-clips or taking off a small piece of the paper tail) some arrangement has to be made for lifting the balloon system to the required height and releasing it by some form of time-fuse. The latter must be simple and within the resources of the ordinary meteorological station using pilot balloons.

It may be mentioned that the direct process of carrying the balloon to the desired height by an aeroplane and then releasing it has been found impracticable, and a " carrier balloon " is used. The real problem is the time fuse, and the experiments were made in the first instance to test various methods of release which had been proposed. The first method suggested by Mr. C. Wilde when at the Meteorological Office, Worthy Down, in 1932, was rather complicated —the tail system of the no-lift balloon included a kind of " harness " made of a ring of aluminium wire and some threads and the complete system included three balloons, first the carrier inflated with hydrogen to give the lifting power, then a balloon which may be called the trigger, attached to the carrier, and then the no-lift balloon attached to the trigger by the harness. The trigger balloon was inflated with air so as to distend the harness ; it was fitted with a plug of hard wood, an aperture in which allowed the air content to leak away, so that after a time, determined mainly by the size of the leak, the trigger balloon deflated enough to slip clear of the harness and the no-lift balloon was left floating free. Much time was taken up by the preparation for an ascent by this method and a simpler method, proposed by Mr. B. A. Copping, of Upper Heyford, in 1934, was tried using an ordinary pilot balloon lantern attached to the carrier balloon. A thread was taken from the no-lift system through a hole in the cardboard base of the lantern and looped round the candle at a suitable distance from the top. The time taken by the candle, lighted just before release, to burn down to the thread loop determined the time at which the separation from the carrier balloon took place. The third method, also due to Mr. Copping, which proved to be the most satisfactory and was used in 70 per cent. of the experiments, involved the use of a small piece of wick such as is used in cigarette lighters. The wick was put in a loop of the thread which joined the carrier to the no-lift system, a suitable length being measured and lighted just before the start of the ascent. After the desired interval, the wick having burnt down to the thread, the thread was burnt through and the carrier separated from the no-lift system. Impregnation of the wick with potassium chlorate was proved to be an unnecessary refinement.

Once the no-lift system has been released at the desired level, readings of the pilot balloon theodolite are made at 1-minute intervals and the working-up resembles an ordinary pilot balloon ascent by tail method. In launching the no-lift balloon attached to the carrier it was found best to lay the tail on the ground in a down-wind direction. For convenience in balancing, the paper tail was rolled into a cylinder round which the thread was wound ; after balancing, a wooden spindle thrust through the cylinder allowed it to revolve freely when the thread of the tail was being unwound before launching.

The number of experiments made at various times between April 23rd, 1934, and January 31st, 1936, was 31. The no-lift balloons were released at heights between 1,000 and 2,000 feet above ground and the position of the balloon at each minute determined by the usual method for pilot balloons ; the rates of ascent during the one-minute periods were evaluated, these being the magnitudes of up- and down-currents in the one-minute periods, assuming the no-lift condition to have been achieved.

The ascents were classified in the following way, the progression of the classes being in order of increasing topographical irregularity of the tracks of the balloons :—

Class a. Trajectory of balloon towards NE., above flat ground.

Class b. Trajectory of balloon towards E., above flat ground to sea-shore.

Class c. Trajectory of balloon towards SE., above river and gently-rising ground.

Class d. Trajectory of balloon towards S., above narrow part of river and rising ground.

Class e. Trajectory of balloon towards W., above rising ground.

The results of examining the ascents in these classes are shown in Table I.

TABLE I

Class	A	B
a	− 29	+ 90 to − 190
b	− 4	+ 180 to − 270
c	+ 21	+ 200 to − 110
d	+ 58	+ 475 to − 180
e	+ 49	+ 400 to − 200

A. Mean velocity of vertical currents measured.

B. Range of velocity of vertical currents measured. The units are feet/minute.

Although the number of observations is not large enough to be fully representative, the regular progression shown in the table suggests that the classification is suitable, the vertical currents being mainly " dynamical turbulence." Observations of upper-air temperature being not available, the ascents were examined with regard to association with stratiform and cumuliform cloud, but the results were inconclusive.

There were five ascents which did not fit in with the above classification ; three of them, when the balloon was travelling above flat ground or water surfaces, showed up-currents more appropriate to sloping ground, as shown in Table 1. The results were attributed to thermal turbulence of a degree not present in the other ascents. One showed an average descending current of −65 feet/minute above flat moorland on a summer day. The remaining ascent was made in the region ahead of an occluded front, and the no-lift balloon showed a continuous ascent averaging 260 feet/minute and ranging from 420 to 100 feet/minute (upward velocity). The isallobaric wind component at the time of observation was about 10 mi./hr. and rainfall at the rate of about 2 mm./hour started at the time of the ascent. No other case of this kind occurred during the experiments and it would be desirable to have other ascents made under similar weather conditions, as a slight error in the balancing of the no-lift balloon would give a fictitious value for up-currents caused by convergence.

Summarising the experiments it may be said that the up-currents measured are on the whole small and of the order found in previous work (using other methods) by various investigators, when account is taken of the slopes of ground and wind velocities involved.

Correspondence

To the Editor, *Meteorological Magazine*

Divergent Isobars and Winds

Owing to some aberration, I wrote "convergence" instead of "divergence" in the third sentence of my note on this subject! Actually the effect of the curvature of the path of the air is entirely negligible in the case of the published mean isobaric charts for the droughts of 1921 and 1933, but might be appreciable on the 1887 chart. Since numerical methods cannot be applied to the accelerations on average charts, it would be best to investigate ordinary daily charts in the first place. In the case of a typical travelling wedge of high pressure, the relative motion of the air mass is from front to rear, so that the divergence is in front of it, the convergence behind it. The situation is reversed if the air movement is through the wedge from rear to front. This is rare at low levels, and, when it occurs, the movement across the wedge is normally exceedingly small and the corresponding accelerations are also small.

C. K. M. DOUGLAS

Meteorological Office, London, August 26th, 1938.

Snow in June, 1938

At 10h. G.M.T. on Saturday, June 9th, during a heavy north-westerly squall there was a shower of snow here lasting nearly five minutes. The flakes were big white flakes such as one associates with a winter's storm. The flakes eventually became mixed with rain, terminating in a squall of rain. The same shower also passed over Liverpool a few minutes later and was freely reported in the Press.

Eric F. Robson

St. Andrew's Vicarage, West Kirby, Cheshire, August 3rd, 1938.

Radiation Frosts in August

That inland stations in south-eastern England at times experience decidedly " Continental " climatic conditions is well known, and the exceptionally low night minima at valley stations such as those recorded from time to time in this magazine by Mr. E. L. Hawke at Rickmansworth, Herts, are of considerable interest.

The meteorological station at Goff's Oak, although in the same county, is not a valley station, being in fact on the summit of a fairly steep ridge of hills. This being so, radiation frosts are not usually experienced in summer months.

On the night of August 20–21st, 1938, however, the grass minimum fell to 29·3° F.—the first radiation frost recorded here in August since the station was opened in the year 1934. The night was very clear, visibility excellent and the mean wind speed at 23 ft. above the soil was only 2·7 m.p.h. The screen minimum was 41° F. so that radiation appears to have been very active. This frost seems to have been the first recorded in this district in August for at least 13 years, since grass minima are available back to the year 1925 from Waltham Cross, a valley station 3½ miles to the south-east, where the lowest grass minimum previously recorded in this particular month was 32° F. on the night of August 25–26th, 1931.

Donald L. Champion

Meteorological Station, 7, Robinson Avenue, Goff's Oak, Herts,
21st August, 1938.

Tornado-like Cloud at Shoeburyness, July 5th, 1938

At 11h. G.M.T. on July 5th, 1938, at Shoeburyness, Essex, the sky was covered with 8/10ths cumulonimbus and fractonimbus cloud (height of bases estimated at 1,800 ft.) and 1/10th " anvil " cirrus. Several inverted conical shaped clouds, one of exceptional clarity were seen to be drawn out of the fractonimbus at the base of a very large cumulonimbus over the sea about three miles east of the station. Heavy rain was seen to be falling from this cloud at the time of observation and a thunderstorm followed at 11h. 30m. G.M.T. The phenomenon was, in appearance, similar to the cloud formation of a waterspout and disintegrated with great rapidity after lasting

2 or 3 minutes, the "funnel" breaking up into very small individual cloudlets which were drawn up into the main clouds. The "funnel" did not quite reach the ground. Meteorological conditions at the time of observation were :—

Surface wind, NW. 2 mi./hr. Visibility, 6–11 miles. Dry bulb, 53·9° F. Humidity, 92 per cent. Barometer, 1001·7 mb. (m.s.l.) tendency unsteady, rising slightly.

A. SCRAGG

Meteorological Office, New Ranges, Shoeburyness, July 5th, 1938.

A Miniature Tornado at Cranwell, May 17th, 1938

The first appreciable rainfall at Cranwell since April 29th was heralded by a cloud pendant which was observed at 17h. 15m. G.M.T. on May 17th, 1938, to be moving in an east-north-easterly direction from a point near the village of Caythorpe towards the aerodrome. The anemometer trace showed that the wind veered sharply from south to north as the storm passed overhead, with gusts from 2 mi./hr. to 20 mi./hr., later backing to north-west. Heavy rain fell with the passage of the storm, some 30 millimetres of rain being measured by the recording raingauge from 17h. 15m. to 18h. 20m. G.M.T., and moderate rainfall continued for the next 23 hours. Thunder was heard locally.

In a field about half a mile from the anemometer the path of a tornado-like disturbance was found later traced by tree cuttings which were distributed across the field by the wind for a distance of 300 yards from the point where they had been stacked. The debris was confined to a track 20 yards wide, and must have been lifted over a wall 3 feet high.

R. E. BOOTH

Meteorological Office, Cranwell, Lincs, May 25th, 1938.

Wind Erosion in Scotland

The weather of April 2nd, 1938, at Montrose should not pass without remark, for a full gale wrought unusual devastation on the ploughed and sown land. March, 1938, at Montrose was very dry and warm; 60° F. was exceeded for the first time this season on March 11th (c.f. May 23rd in 1937 !) and 65° was reached before the end of the month. Rainfall totalled 0·28 in., most of which fell in slight showers of brief duration and dried quickly from the land. Humidities under 60 per cent. were measured on ten days of the month, with an extreme reading of 34 per cent. on the 25th. In some respects the season is two months ahead of last year, and it has been proclaimed the best season for sowing for at least 50 years in this part of the country.

Thus the light soil, lately sown or turned by the plough, was in a very vulnerable state when on April 2nd at 9h. G.M.T. a west-south-westerly gale increased to force 9. The violence of the gale was not experienced at Leuchars or Aberdeen, and may have been due here to converging air-streams near the southern face of the Grampian Mountains. The wind blew at Montrose with force 9 to 10 from 8h. 40m. until 11h. Winds of force 6 to 7 in the foregoing week had shown signs of lifting the topsoil from the many fields whose soil had been turned ; and now a great cloud of soil was raised to the treetops, reducing visibility as far as the coast. On one main road visibility was 15 to 20 yards from 9h. till nearly 11h. ; and afterwards the soil lay to an even depth of 4 inches across the road, with some drifts 1 foot deep. Traffic was in difficulties and few cyclists or footwalkers made their way through owing to the sting of the flying earth along 200 yards of roadway. In spite of this accumulation near hedges and on roadways a large proportion, possibly half, of the lifted soil was blown out to sea and lost forever.

It would seem therefore that big, flat, open fields with only low hedges, or none at all, are occasionally liable to serious erosion even in Britain. One big field in this case lost all its topsoil, leaving only a stony bed at which point the soil ceased to blow, an hour before the wind dropped. In the U.S.A. such erosion has been common in recent years. The writer has seen one similar storm of blowing earth, although less extensive, in the wide open fields of the Fenland, but Scotland is more liable to violent winds than eastern England.

H. H. LAMB

Meteorological Office, Montrose, Angus, April 6th, 1938.

Rainfall on July 29th–30th, 1938

A remarkable rainstorm occurred along a belt including parts of Ireland, northwest England and southwest Scotland on July 29th and 30th, with the heaviest falls in the Lake District. During the 24 hours ending 17h. G.M.T. on the 30th, Ambleside reported a rainfall of 4·40 in., following a fall totalling 1·48 in. in the preceding 48 hours. The totals for the rainfall days of the 29th and 30th amounted to 8·06 in. at Borrowdale and 7·45 in. at Watendlath Farm in an adjoining valley. The rainfall occurred in a pronounced southwesterly current, mostly in the warm sector close to a slow-moving cold front, which was so poorly defined that its precise correct position is doubtful. This meteorological situation is favourable for heavy rainfalls, especially in hilly districts. A good example, on Nov. 2nd to 3rd, 1931, is described in detail in *British Rainfall*, 1931, pp. 67–73.

C. K. M. DOUGLAS

Meteorological Office, London, September 2nd, 1938.

NOTES AND QUERIES

The Effect of Wind on the Temperature of a Thermometer

In the *Meteorological Magazine*, July, 1938, p. 142, Col. Gold discusses the effect of a high velocity air stream on the temperature of a thermometer, on the assumption that the kinetic energy of the moving air is transformed into heat energy by the action of an obstacle—in this case, the thermometer bulb. Col. Gold says " Thermometers exposed freely on aeroplanes may pass through the air at . . . higher speeds, and have their temperatures affected by several degrees F.—nearly 30° F. for a really fast plane of 400 m.p.h." The reading of a freely exposed thermometer moving at such a speed would not necessarily, however, be 30° F. above the temperature of the surrounding air ; this result could only be affirmed for an insulated thermometer placed at the stagnation point of a bluff body moving at 400 m.p.h. A freely exposed thermometer bulb (supposed cylindrical shape) would be in contact with the still air at 30° F. above the true air temperature over a small area only ; elsewhere, the air would be moving around the bulb at a pressure lower than the stagnation pressure, and its kinetic energy would not be wholly transformed into heat energy. At the rear of the body, the pressure reaches a minimum with the formation of a turbulent wake. The true temperature of the thermometer is a result of (1) conduction of heat from the still air at the stagnation point, (2) conduction of heat from the moving air at varying pressure and temperature up to the point of separation, (3) convection of heat by the eddies in the wake and (4) any frictional heat developed. The problem of the determination of the mean temperature of the bulb is thus difficult, being analogous to that of finding the drag and so depending, among other things, on the shape of the bulb. In view of the fact that convection is usually much more important than conduction in problems of heat transfer, one might anticipate that the reading of a thermometer of conventional shape would not differ vastly from the true temperature of the air, even at the speed of a modern aeroplane, but how far this is realised in practice I do not know.

When really high speeds are considered the problem is different. It is a fact of experiment that a thermocouple placed in a high velocity jet of air in a divergent orifice connected to a high pressure reservoir records, not the expected low temperature due to the adiabatic expansion, but the temperature of the unexpanded air in the reservoir. Pohlhausen* has thrown light on this by examining the case of an ideal thermometer in the form of a thin lamina placed along the direction of flow, making use of Blasius' boundary layer solution. Stodola, in his treatise on turbines[†], commenting on this result, says "No method is known that will determine the true temperature in flowing fluids. The friction of the fluid against the thermometer or thermocouple generates heat affecting the readings to an extent yet unknown."

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* *Zeit. f. angew. Math. u. Mech., 1.* (1921.)

In view of the high speeds which may be attained in stratosphere flights in the future, it is of interest to consider what is known of the behaviour of compressible fluids as regards heat transfer. In a recent paper[‡], Kàrmàn and Tsien have considered, among other things, the flow of heat from a body whose temperature differs from that of the surrounding high speed stream. They give a general relation between drag and heat transfer as a function of Mach's number (ratio of the fluid velocity to that of sound at the same temperature), and find that cooling ceases at certain values of Mach's number, depending on the ratio of temperatures of the body and the fluid. A similar result has been found experimentally by Santon[§] for hot wire anemometers in high speed streams. For low velocities the wire is cooled by the air stream but for velocities above 0·8 of that of sound the temperature of the wire rises as the speed increases.

The relationship that exists between heat transfer and drag suggests that some consideration should be given to the shape of the bulb in the design of thermometers for use with high speed aircraft. Of equal interest to meteorologists is the behaviour of a wet bulb in a high velocity current but, as far as I am aware, this problem has never been considered on the lines indicated above.

O. G. SUTTON

I thought I had provided a protective shelter for the vital part of my Note by the statement: "Actually there is certain to be some departure from the adiabatic law, depending among other things on the shape of the thermometer." But Mr. Sutton has struck a little lower down, metaphorically, like Joab, under the fifth rib.

The thermometers used for meteorological observations in aeroplanes in this country usually have their bulbs in a metal honeycomb, through which the air streams past the bulbs. The honeycomb is like a metal box of dimensions 4 in. by 3½ in. by 1¼ in. open at both ends. The air stream is parallel to the 4 in. side. The honeycomb openings are about ¼ in. square and they extend for about ½ in. from each end, the intervening 3 in. being an open space except for the bulbs of the thermometers. The dry bulb thermometer is about ½ in. behind the front honeycomb and the bulb of the wet bulb thermometer about ½ in. from the rear honeycomb. The bulbs are about ½ in. in thickness and there is one inch clearance between them. Thus the air strikes on the dry bulb first before it reaches the wet bulb. Such observations as I have seen indicate that the effect of the motion of the aeroplane on the temperature of the thermometer is nearly equal to the adiabatic effect. This does not apply to the wet bulb for which the increase of temperature is much smaller, but the difference between the effect on the wet bulb and on the dry bulb is not due to the shielding of the dry bulb, because if the wet bulb is run (in the same position) as a dry bulb instrument, i.e. with the muslin dry, the temperature effect on both thermometers is about the same.

[†] "Steam and Gas Turbines," *trans.* Lowenstein (1927).

[‡] Kàrmàn and Tsien, "Boundary Layer in Compressible Fluids," *Jour. Aero. Sciences*, 1938. *5* (6), pp. 227–32.

[§] L. Santon, *Pub. Scient. et Tech. du Ministère de l'Air*, No. 68 (1935).

Mr. Sutton suggests that if the thermometer were exposed without the protective honeycomb the temperature recorded by it would not be far different from that of the air through which it passed ; but I do not think he gives any good grounds for his opinion and the fact which he mentions in the next paragraph that " a thermocouple placed in a high velocity jet of air in a divergent orifice connected to a high pressure reservoir records, not the expected low temperature due to the adiabatic expansion, but the temperature of the unexpanded air in the reservoir," suggests that the thermocouple is heated substantially by the air moving with high velocity which it brings to rest temporarily.

Fortunately the problem is one amenable to experimental treatment in the atmosphere, as the true temperature of the air through which an aeroplane moves rapidly at a given level can be determined from an aeroplane moving slowly at that level, and the variations of temperature in the distances traversed by the aeroplane are usually small compared with the variations due to speed.

E. Gold

Excessive Rainfall in Southern California, February 27th—March 3rd, 1938

Although the recent floods in southern California caused far greater damage and loss of life than have ever been known before in that part of the world, neither in total amount nor in intensity of rainfall was a new record created. The nearest approach to the millions of dollars of damage and serious loss of life so recently experienced, was that resulting from the Long Beach earthquake of March, 1933. Apart from this, the only other serious catastrophe which has occurred in the region came about through a combination of causes rather than through one single element. In this case an enormous forest fire denuded miles of mountain side in the early autumn of 1933, after which a complete drought prevailed until the record storm on New Year's Eve. It was on this occasion that the all-time record for intensity of rainfall in southern California was broken. Seven and a half inches were measured in 24 hours at the U.S. Weather Bureau station in Los Angeles and amounts up to 13 inches for the same period in the smaller towns which lie along the base of a range of mountains a short distance to the north. Torrential rainfall washed down the bare, burnt-over mountain slopes and a village which happened to be in the path of the flood waters was completely wiped out.

In comparison the total rainfall in Los Angeles for the storm of last winter was eleven inches; it fell fairly continuously over a five day period. It is interesting to discover that on both the occasions mentioned the weather charts showed a similar type of synoptic situation and the same explanation can be given to both phenomena. As a matter of fact, the meteorological situation was not exceptional and is by no means of infrequent occurrence.

Southern California lies just north of the 35th parallel of north latitude and is placed in the belt of sub-tropical or Mediterranean type climate. Geographically the region is bounded to the north and east by mountain ranges averaging 6,000 feet in height but which contain occasional peaks and passes where the general level may rise to 10,000 feet or fall to 3,500 feet. The coastline runs in a northwest–southeast direction and apart from a few ranges of low hills the coastal plain extends inland to the foothill towns at the base of the northern mountain range. Taking a due north-south line passing through Los Angeles, from the ocean to the mountains, (see fig. 1) the coastal plain would extend 30 miles inland and this distance would decrease to the west and increase to the east of this line; Los Angeles itself would be found two thirds of the way inland along this line. The northern mountain range runs almost due east and west while that to the east is much more irregular in its direction almost approaching the coast in its southern portion but extending a hundred miles inland further north. On the outer sides of both ranges, however, are arid deserts upon which less than three or four inches of precipitation falls annually.

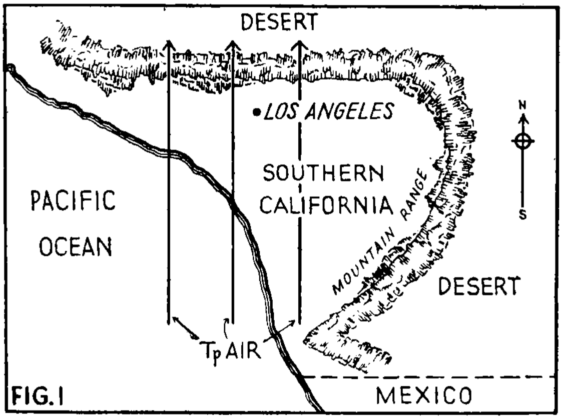

Fig. 1.

The main source of the rainfall of southern California is the winter overrunning of Polar Pacific (Pp) by conditionally unstable Tropical Pacific (Tp) air. Rain falls on comparatively very few days of the year but while it lasts it is usually fairly heavy and after two or three days of rain the sky frequently remains cloudless for several weeks. The total amount of rainfall slowly increases as the coastal plain slopes northward. Annual averages of ten inches are reported from coastal towns, of 25 inches at Pasadena in the foothills and of over 40 inches in places on the higher windward slopes of the mountains. The average monthly rainfall for Los Angeles is shown in the following table :—

Monthly Table of Average Rainfall in Los Angeles (1877-1937).

Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
3·15	3·10	3·00	1·00	0·50	0·10	0·00	0·00	0·20	0·75	1·20	2·75	15·75

The number of rainy days is about the same for all stations so it can be seen that the orographic effect is a most important factor in the intensity of precipitation.

Towards the end of February, 1938, the semi-permanent Hawaiian anticyclone which is responsible for the normal dry weather periods receded southwards and the main polar front approached the subtropical latitudes. Pp air occupied the region to the north, Tp air that to the south. Several waves formed on this front and developed into depressions which occluded and moved eastwards over the continent. The Tp air, however, was not true equatorial air, but greatly modified old Polar Siberian air. This originally continental mass remained cold in its upper levels and during its slow passage over the long semi-circular trajectory between Japan, the Hawaiian Islands and the coastline of southern California it gained a vast amount of available energy in the form of warmth and moisture from the ocean. By the time this mass had reached the American coastline it was extremely unstable—but only conditionally unstable ; an initial lifting force was necessary to release the instability.

In southern California the lifting force is provided either by warm front overrunning or by the orographic effect. The Aleutian " low " affects the weather of the western coasts of America rather as the Icelandic " low " affects the weather of the British Isles. When a depression is moving eastwards over the north Pacific Ocean the upper winds in the warm air ahead of the warm front will be frequently due south. Warm air will then flow normal to the east-west lying mountain range and there will be the additional lifting force present. Once the air has been started on its vertical course the total amount of its instability becomes released.

Meteorological data for the five-day period February 27th–March 3rd, 1938, clearly demonstrate this process taking place. A southerly gradient wind averaging 50 m.p.h. between 4,000 and 7,000 feet forced the warm air rapidly upwards. Aerological soundings showing high negative values of $\frac{d\theta_E}{dh}$ (change of equivalent potential temperature with height) gave proof of the conditional instability of the air. When the charts showed a brief veer of the upper wind as a front passed by the rain temporarily slackened or ceased but it restarted with great intensity when the wind again backed to its former southerly direction.

An unusual but interesting phenomenon with regard to the length of the period of continuous rainfall and its intensity in these examples of excessive rainfall is the entrapping of the cold air below the mountain range (*see* fig. 2).

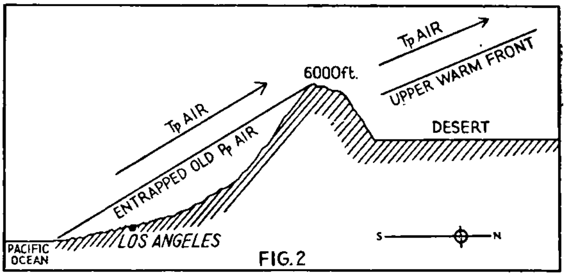

Fig. 2.

As the warm front advances inland it lines up with the mountain ranges—the upper part of the front breaks off and continues on its course as an upper front. The lower part remains stationary some distance away from the mountains and as long as the warm air continues to flow normal to the range and overrun the colder air this situation will remain unchanged. This explains the large extent of rainfall in places a considerable distance away from the mountains

I should like to express my gratitude to Dr. Irving P. Krick of the Meteorology Department of the California Institute of Technology for the help he has given me in providing me with copies of his charts.

A. H. Gordon

Sand Devils at Heliopolis

A considerable amount of information is now available regarding sand devils at Heliopolis and a discussion of the observations for the period 1927–1936 may be of interest. In Professional Note No. 71 of the Meteorological Office, Mr. W. D. Flower discusses the results of observations in Egypt, the Sudan, and Iraq during the period 1927 to 1932. His discussion has been borne in mind in what follows.

The total number of sand devils observed at Heliopolis in the period 1927–1936, was 138. This does not mean that only that number of sand devils developed. In summer, sand devils are regarded as a normal feature of the weather and, unless they develop near the observer or are of exceptional size or violence, they often pass unrecorded. The frequency of sand-devils varies with the time of day, and with the idea of finding what relationship, if any, existed between it and the diurnal variation in lapse rate near the ground, a series of simultaneous readings of the temperature of the ground surface and of the air in the thermometer screen was made. The results of these observations are given below :—

TABLE I.—LAPSE OF TEMPERATURE BETWEEN GROUND SURFACE AND THERMOMETER SCREEN

(Temperature of the ground obtained from thermometer lying on ground, its bulb covered with thin layer of sand and only its index showing.)

Local Time	0600	0700	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700	1800
	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
May 1, '35.	—	—	—	—	22·8	23·1	25·0	28·2	25·6	21·0	11·6	1·5	−3·9
May 2, '35	−5·3	0·9	3·8	12·2	19·5	—	27·6	—	26·2	21·5	16·8	4·5	−3·1
May 3, '35	3·0	9·8	15·1	19·8	—	24·3	29·0	32·2	24·9	20·9	17·4	—	3·3

The greatest lapse rate apparently occurs at 1300h. L.T. (1100 G.M.T.) the hour around which the greatest number of sand devils develop. From 1100h. to 1500h. L.T. inclusive, the frequency of sand devils was 92 per cent. of the total number observed at all hours. Their size and violence does not appear to bear any relation to the time at which they occur but the larger dust devils seem to develop over certain small areas, one of which is the centre of the aerodrome, clear of obstructions. The annual variation in the frequency of sand devils is similar to that found by Flower. None were observed in December, January and February, the percentage frequencies in the other months being : March, 4%, April, 9%, May, 14%, June, 9%, July, 28%, August, 13%, September, 17%, October, 4% and November, 1%. The dip in the curve of annual frequency for the month of June is a characteristic also found by Flower.

Although sand devils occur during the hottest months, they need not necessarily occur on the hottest days. This may be because high surface temperatures need not necessarily be accompanied by the lapse rates appropriate to their formation whatever these may be. The association of high lapse rate with the occurrence of sand devils as brought out by Table I above may be used in estimating upper air temperatures when no other information is available. The unusual bumpiness whilst flying in the vicinity of sand devils has frequently been commented on by pilots and the evidence of the anemometer is that they are invariably accompanied by gusty conditions, wind directions oscillating through 90 degrees or more and occasionally boxing the compass. The results of 17 pilot balloon observations carried out in 1936, in the early afternoon when dust devils were forming are given in Table II. The method of observation was the " tail " method, so that vertical currents could be observed.

TABLE II.—VERTICAL CURRENTS ON SAND DEVIL DAYS IN 1936. (ASCENTS ABOUT 1500 L.T.)

Date.	Sand Devils Observed.				Vertical current in feet per minute.				
	Local Time.	*Rotation.	Height in feet.	Base in feet.	1st Minute.	2nd Minute.	3rd Minute.	4th Minute.	5th Minute.
March 19th	1330	A	5	3	140	100	−190	−110	—
March 31st	1300	A	50	10	150	60	−140	130	−60
April 3rd	1305	A	50	40	580	420	250	110	−120
May 29th	1357	C	500	40	210	230	440	450	370
June 16th	1305	C	200	3	270	270	270	270	†270
June 23rd	1300	C	400	10	150	−40	110	130	40
July 12th	1330	C	300	5	−15	−5	−50	0	180
July 18th	1310	A	200	30	−50	−50	−60	−300	−240
August 16th	1420	C	200	3	170	280	30	20	−150
August 22nd	1445	A	200	50	−145	−155	−260	−230	−180
August 31st	1255	C	1,000	10	20	0	30	−360	100
September 3rd ...	1510	A	50	50	−20	−130	−190	−180	−410
September 6th ...	1510	C	200	4	170	90	40	20	10
September 12th ...	1257	C	200	3	210	410	140	190	90
September 15th ...	1506	C	100	2	50	150	80	−20	−60
September 30th ...	1256	A	30	8	−70	−70	10	80	150
October 7th	1145	C	2,000	10	188	90	20	20	−80

* A = Anti-clockwise, C = Clockwise. † Average.

On five occasions these reveal downward currents in the layer affected by the sand devil and there are other indications that such currents occur, sometimes associated with a fall in temperature. Incidentally, in regard to the change of temperature, it may be remarked that the arrival of relatively cool, moist Mediterranean air during the early afternoon is often accompanied by a line of sand devils. It seems, however, that once this air is established conditions are no longer favourable for the development of sand devils. Table III gives the percentage frequencies of specified estimated heights and diameters of the sand devils discussed in this note.

An extraordinary feature is the apparent change in the sense of direction of six of the sand devils observed. However difficult it may be to interpret this observation its accuracy is vouched for by the observer. In Table III the sand devils are classified according to their sense of rotation.

TABLE III.—DIMENSIONS AND SENSE OF ROTATION.
PERCENTAGE FREQUENCIES.

Sense of Rotation.	Estimated Heights in Feet.						Estimated Diameters of Base in Feet.				
	Under 50	50–100	100–200	200–500	500–1000	Above 1000	Under 5	5–10	10–20	20–40	Over 40
	%	%	%	%	%	%	%	%	%	%	%
Clockwise	12	23	13	9	7	1	27	18	7	7	0
Anti-clockwise ...	4	4	3	4	1	0	1	4	3	1	1
Anti-clockwise, becoming clockwise.	1	2	0	0	0	0	2	1	0	0	0
Clockwise, becoming anti-clockwise, then clockwise.	1	0	0	1	0	0	0	0	0	1	0
Doubtful... ...	14						27				

WM. JAMES

Oldham Road, Manchester

After more than 57 years of regular service the climatological station maintained by the Manchester Corporation at 299, Oldham Road, has been closed. The station was established in 1881 by the Public Health Department within the grounds of one of the Cleansing Committee's yards and the statistics which it furnished have been included regularly in the annual report on the health of the City of Manchester. Since 1892 the station has also been in co-operation with the Meteorological Office, and the readings have been included in various periodical publications devoted to climatological data. Early in 1938 it became known that the ground was wanted for a workshop and the readings ceased at the end of June.

Situated as it was in the very heart of industrial Manchester, and surrounded on all sides by buildings, the exposure of the station was unorthodox, but it served a very useful purpose as representing the characteristics of a thoroughly urban site. It is perhaps not fully realised that most of our data for large towns are derived from park sites, the micro-climates of which may differ quite noticeably from those of the congested areas in which a large proportion of the inhabitants live, or of the factory areas where the industries are carried on. Oldham Road was one of the very few stations which provided information relating to the latter class of terrain. A careful comparison between the Oldham Road records and those of the station at Whitworth Park maintained by the University of Manchester would undoubtedly bring to light many interesting points.

Oldham Road was perhaps best known on account of its very low sunshine records, the average daily duration being only 2·65 hours. It should be noted, however, that the exposure of the recorder was badly obstructed by buildings and it is estimated that these reduced the daily record on the average by about six per cent. Making this allowance the Oldham Road value comes into close agreement with the daily average at Whitworth Park, 2·82 hours, and that figure is probably about correct for central Manchester as a whole.

REVIEW

Climate, A treatise on the principles of weather and climate. By W. G. Kendrew, M.A. 2nd Ed. Size 9 in. × 5½ in., pp. ix+327, *Illus.* Oxford, at the Clarendon Press, 1938. Price 15*s*. net.

The first edition of this work was reviewed in this Magazine for May, 1931 ; in the new edition there has been a considerable amount of revision, the most extensive alterations being, according to the author's preface, in the chapters dealing with insolation and wind systems. The general plan of the book remains as before, a short introductory chapter, which gives the scope of climatology, being followed by parts II to X, on insolation and temperature ; pressure and winds ; humidity, rainfall, evaporation, clouds, thunderstorms ; sunshine and cloud (cloudiness) ; fog ; mountain and plateau climate ; the weather of temperate regions ; local winds ; and, finally, some climatic types—the Sudan, the Mediterranean type, the Westerlies.

In such a tremendous array of facts, it is not surprising if even in a second edition some points remain for comment, and attention may be drawn to the following :—page 31, probably lower temperatures are found at Oimekon in Siberia than at Verkhoiansk ; page 69, some more explanation should be given of the statement that mean pressure is constant for any given place and season ; page 72, the explanation of the relation of barometric gradient to wind force might be extended, with some more data than those quoted from Whipple and Baker ; page 118, the term " rainy day " suggests a larger fall than 0·01 in., the official quantity for a " rain-day " in this country ; page 122 mentions quantity of water vapour measured in grains per cubic foot and page 187 gm. per cubic metre but the tables of equivalents at the end of the book do not mention these units ; page 125, the conditions in which ions act as nuclei for condensation might be mentioned ; page 197, the whole story of the Sahara is not given by data for Helwan ; page 210, fog is usually defined by visibility below 1,100 yards. The section on the weather of temperate regions (p. 239 ff.) includes an interesting account of weather systems which affect our weather.

There may not be complete agreement, however, about what goes on inside a depression. On several of the weather maps are now marked "fronts" in the conventional symbols. The fronts are stated to be based on Norwegian daily charts. Misprints are few—the figures for heights of mother-of-pearl clouds and luminous night clouds on page 172 have been interchanged; the only other misprint noted is in the quotation from Tacitus (on page 200) which is an early example of the comments made by visitors on the weather of this country.

Apart from these points there are a few which might to some extent be regarded as amongst the "matters of theory on which unanimity is hardly to be expected" mentioned in the preface, but in regard to which the student should be given something of the more modern views. On page 78 appears a diagram stated to be a diagrammatic sketch of the arrangement that might (1st edition—"probably would") be found on the globe if the surface were homogeneous. The term planetary circulation is not used, but the diagram seems to be the usual one. Let the student who has mastered Chapter XV sketch in the isobars over this ideal circulation and he will find that the idea of a cellular circulation in the sub-tropical highs is more satisfactory. On page 17 more of the whole story of the "greenhouse effect" should be given—the main action of the glass is in stopping convection. The Brückner cycle, as everyone knows, is of 35 years, but a 35-year cycle is not so easy to find in the data as cycles of 33, 34 or 38 years. Whether any of these would be better for reaching the true mean value depends on what a true mean value is, an argument which could be expanded into a separate treatise. More can be said about the formation of stratocumulus cloud than the description as a combination of stratus and cumulus (page 174). There are limitations to the goodness of the approximation given by mean of maximum and minimum temperatures to the true mean for the day (page 19). A hurricane area has been found in the *eastern* equatorial sector of the Pacific. The 12 plates, most of which are reproduced from very fine photographs of meteorological phenomena such as the banner cloud and the tornado, and 117 diagrams illustrate the text very well, and on the whole the work may be recommended as a useful and interesting account of the principles of weather and climate, as well as a very good example of printing.

S. T. A. MIRRLEES

BOOKS RECEIVED

County of Surrey: Rainfall statistics for the county for the year 1937. County Engineer, Guildford, 1938.

Meteorological report from readings taken at the Greg Observatory, Lancaster, 1937. Neville Holden, Lancaster, 1937.

Jahrbücher der Zentralanstalt für Meteorologie und Geodynamik Jahrgang, 1935. Pub. No. 149. Wein, 1938.

Annales del Observatorio Nacional de San Bartolome en los Andes Colombianos. Obs. Met. de 1934. Bogota, 1937.

ERRATA

March, 1938, p. 52.

The rainfall at Adelaide in February (2·45 inches) has been exceeded on 7 occasions.

June, 1938, p. 130. line 9. *For* Adelaide *read* Brisbane.

The Weather of August, 1938

High pressure was centred north of the Azores and a low was situated off western Greenland. Pressure was mainly uniform over Europe being slightly below normal over southern Europe and the Mediterranean Basin and above normal over the North Atlantic Ocean and northern Europe. At 50° N. 30° W. there was a mean pressure of 1018 mb., 5 mb. above normal whilst at Sortavala, Finland 1016 mb., 6 mb. above normal was recorded. Over North America pressure was fairly uniform, the north-east and centre being below normal and the south, coming under the influence of the Azores anticyclone, was above normal, whilst off the western Canadian coast pressure was relatively high, Prince Rupert and Juneau, Alaska each recording 1019 mb., 2 mb. above normal. No data were received from the U.S.S.R. Temperature ranged from 40° F. over Spitzbergen, south-eastern Greenland and the mouth of the Hudson Bay (Isfjord Radio 40·6° F. Myggvukta 39·9° F. and Resolution Island 36·4° F.) to 80° F. over northern Africa and the southern United States (New Orleans 84·6° F.) and 90° F. over south-west Asia (Mosul 89·4° F.). Over the Great Lakes and centre of North America and the Baltic Sea temperature was above normal, these being included in the 5° F. isanomaly, elsewhere over North America and Europe small deviations from normal were experienced ; southern Europe and the western Mediterranean were below normal while the eastern Mediterranean was above normal. Rainfall was heavy over central Europe, light over the eastern Mediterranean and mainly below normal in Sweden ; stations in Egypt, Palestine and Iraq have recorded no rain, which is normal for the season. The wettest parts of North America were the area between the Great Lakes and the Hudson Bay, and off the Gulf of St. Lawrence, Sable Island having the largest rainfall of 5·5 in.

Pressure was high over south-eastern Australia and low over southern China ; the highest recorded pressure was at Bourke with 1022 mb. Over the East Indies, the Malay States and northern Australia pressure was below normal (Boulia — 7 mb.) while over the south of Australia and New Zealand it was above normal. Temperature was mainly normal over southern China, Siam, the Malay States, the East Indies, south-eastern Australia and New Zealand, western Australia being below normal where Onslow with a temperature of 60·3° F. was 6·3° F. below normal, and north-eastern Australia was above normal (Boulia 69·8° F., + 6·3° F.) Heavy rain fell in Indo China, at Vientiane over 20 in. fell (nearly 9 in. above normal); more than 7 in. was recorded in western Australia and in the south part of North Island New Zealand. There was a marked deficiency of rain over the Philippine Islands, Manilla rainfall was more than 6 in. below normal. Rainfall in east and north Australia was below normal while the rest of Australia and the greater part of New Zealand was above.

The weather of August over the British Isles was remarkable for frequent thunderstorms, particularly during the first twelve days.* As far as can be estimated at present the total rainfall for the month was below average over practically the whole of Scotland and in most parts of Ireland ; in England and Wales it varied considerably owing to intense local falls of rain during some of the frequent thunderstorms. The month was dull on the whole in England and southern Ireland but sunshine exceeded the average for the most part in Scotland and in the north of Ireland. In the extreme north of Scotland the excessive sunshine was notable ; at Lerwick, in the Shetland Islands, the total was 229 hours, representing an excess of 112 hours above the average. The first twelve days were warm but subsequently the weather became considerably cooler and the last few days were decidedly cool. Much fog was reported from the 1st–12th ; it was persistent and thick at times on the north-east coast of England from the 5th–12th.

During the opening days of the month an anticyclone moved north-east from northern England to the west of Norway. Meanwhile pressure was relatively low over the Bay of Biscay ; thunderstorms were reported in Ireland and the south-western districts of England and Wales but little rain occurred elsewhere. On the 4th a shallow depression was centred south of Ireland and further shallow depressions moved north from France ; thunderstorms were widespread in England and Ireland. The thunderstorms on the 4th were accompanied by unusually heavy rains at numerous places in south-west England ; at Torquay 5·72 in. fell between 6h. 50m. and 12h, of which 4·25 in. fell in 108 minutes from 7h. 12m. to 9h. From the 5th to the 10th a complex area of shallow low pressure covered most of the British Isles, while an extension of the anticyclone over Scandinavia stretched westward to the north of Scotland ; thunderstorms were reported daily from the 5th to the 12th. Temperature was high during the first 12 days ; 80° F. was reached or exceeded at some place or other on each day and among the highest maxima recorded were 87° F. at Camden Square (London) on the 1st and at Poole on the 2nd and 3rd, and 86° F. at Regent's Park (London), Brighton and Tottenham on the 1st and at Bournemouth and Southsea on the 3rd.

Subsequently the Azores anticyclone spread north-east over the British Isles and mainly fair weather prevailed for the most part on the 13th and 14th, though it was considerably cooler. At Lerwick and Kirkwall rain on the 15th ended an absolute drought of 15 days.

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* See p. 195 *et. seq.*

A deep depression south of Greenland and an associated trough extending to south-west Ireland moved east and caused further rain, chiefly in the west and north, between the 15th and 17th. Strong, squally winds prevailed at exposed places in Great Britain on the 17th, with a gale at Wick. A further spell of cool, unsettled weather was associated with the eastward passage of depressions to the north of Scotland; rain fell at times, and gales were recorded locally in the west on the 18th and 19th, while local thunderstorms occurred on each day from the 19th to the 22nd. On the 23rd a wedge of high pressure crossed Great Britain giving a fair day in the eastern half of England but much fog on the south-west coasts. Meanwhile a depression on the Atlantic moving north-east and an associated trough approaching Ireland caused heavy rain in west Ireland and west Scotland on the 23rd and later in north England. Thereafter a belt of high pressure stretching from the Azores across the British Isles to northern Scandinavia occasioned fair weather in many parts on the 25th and 26th, but a trough of low pressure passing east over the country brought renewed unsettled weather on the 27th and 28th. Subsequently pressure was low over central Europe and relatively high to the south-west and north-west of the British Isles. Cool weather prevailed during the last few days, with scattered rain or showers and good records of bright sunshine locally. Low screen minima were registered at some stations on the morning of the 31st, for example 32° F. at Barton, Manchester.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway ..	187	+59	Chester ..	149	−10
Aberdeen ..	199	+59	Ross-on-Wye	129	−43
Dublin	127	−27	Falmouth ..	163	−33
Birr Castle ..	105	−32	Gorleston ..	187	−10
Valentia ..	108	−40	Kew.. ..	158	−25

Kew temperature, mean, 61·3°F: diff. from average, −1·4°F.

Miscellaneous notes on weather abroad from various sources

The first half of August was characterised by a series of violent thunderstorms in Europe. On the 4th, Paris was visited and Le Havre was flooded while in eastern Poland lightning killed 26 persons and started 85 fires. On the 6th storms raged over the northern half of France causing three deaths and much damage, and Le Havre was again flooded, some hailstones being reported to weigh over three ounces. The storms continued for several days; lightning damaged an insulator on the Radio Paris broadcasting station, interrupting the broadcasts during the 9th. Storms occurred in

Brussels and other parts of Belgium on the 8th, the Riviera on the 11th and Paris on the 12th. In North America the month opened with heat and drought, temperature reaching 93° F. in New York on the 3rd and 15th. Crops in Canada were damaged by hail. In India the monsoon rainfall was heavy and floods covered a very large area in the United Provinces. The Nile Food also rose to an unusually high level, submerging wide areas in Egypt and destroying large quantities of cotton. A typhoon passed close to Shanghai on August 10th (*The Times*—various dates).

Daily Readings at Kew Observatory, August, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain	Sun	REMARKS
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1024·3	NE 3	63	84	48	—	10·8	w early.
2	23·9	NE 3	60	82	59	—	6·6	
3	21·2	E 4	59	80	50	—	10·8	
4	16·8	E 4	57	81	46	—	9·4	tl 19h.–20h.
5	15·4	NNW 2	58	79	59	trace	3·6	pr$_0$ 21h.
6	14·8	W 3	62	83	45	—	8·0	
7	14·6	NNE 2	63	67	91	0·55	0·0	ir$_0$–r 9h.–22h.
8	12·6	Calm	63	77	70	0·22	4·8	r$_0$ 3h.–5h., r 5 h.–7h.
9	13·5	S 2	60	79	63	trace	7·1	pr$_0$ 8h.
10	14·9	NW 2	61	67	74	0·43	0·0	r–r$_0$ 3h.–10h. and 13h. 18h.
11	14·1	WSW 1	58	79	61	0·72	9·3	tlr 17h.–20h., R 18h.
12	12·5	WNW 2	56	79	74	0·14	5·5	tlR 17h., tlr 20h.
13	12·7	W 3	57	69	55	—	6·5	
14	14·2	Calm	56	67	73	0·01	0·0	r$_0$ 6h.–7h.
15	15·5	E 1	52	73	54	—	7·7	mw early.
16	06·8	SW 5	60	71	73	trace	3·6	d$_0$ 10h.
17	12·1	W 3	57	68	41	trace	5·2	pr$_0$ 3h.
18	12·8	SW 4	54	70	54	—	6·8	
19	00·0	SSW 5	58	68	89	0·02	1·3	r$_0$–r 11h–12h., pr$_0$ 15h.
20	07·1	SW 4	54	66	56	trace	6·1	pr$_0$ 15h.
21	15·2	WSW 2	45	67	47	0·01	9·1	pr$_0$ 15 h. & 6h.
22	18·9	WSW 2	49	63	64	0·04	0·7	pr$_0$, 10h., ir$_0$ 15h.–18h.
23	21·6	E 3	51	71	51	—	11·1	mw early.
24	19·8	SE 2	53	74	48	—	5·8	w early.
25	19·8	S 2	51	74	48	trace	2·6	pr$_0$ 17h. & 19h.
26	21·3	NNE 2	56	65	65	0·21	2·1	r$_0$–r 0h.–4h.
27	19·3	SW 1	54	71	60	—	3·9	fe till 8h.
28	12·7	SW 2	53	67	62	0·24	0·1	r$_0$–r 7h.–8h. & 19h.–24h.
29	12·1	NNW 4	53	58	83	0·11	0·0	r$_0$–r 0h.–9h.
30	15·1	W 3	45	63	57	—	3·7	w early.
31	1016·6	SW 2	46	64	47	—	5·8	w early.
*	1015·2	—	56	72	60	2·70	5·10	* Means or Totals.

General Rainfall for August, 1938

England and Wales	100
Scotland	68
Ireland	83
British Isles ...	89

per cent of the average 1881–1915.

Rainfall : August, 1938 : England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square..........	1·80	81	*Leics* .	Thornton Reservoir ...	2·86	102
Sur .	Reigate, Wray Pk. Rd..	2·42	99	,, .	Belvoir Castle............	4·10	156
Kent .	Tenterden, Ashenden...	1·89	83	*Rut* .	Ridlington	2·36	94
,, .	Folkestone, Boro. San.	1·83	...	*Lincs* .	Boston, Skirbeck.........	1·95	82
,, .	Margate, Cliftonville....	2·28	118	,, .	Cranwell Aerodrome...	2·20	81
,, .	Eden'bdg., Falconhurst	4·79	183	,, .	Skegness, Marine Gdns.	1·84	75
Sus .	Compton, Compton Ho.	2·16	70	,, .	Louth, Westgate....,....	2·97	106
,, .	Patching Farm..........	1·54	61	,, .	Brigg, Wrawby St.......	2·71	...
,, .	Eastbourne, Wil. Sq....	1·45	58	*Notts* .	Mansfield, Carr Bank...	1·67	60
Hants .	Ventnor, Roy.Nat.Hos.	1·39	70	*Derby* .	Derby, The Arboretum	1·59	95
,, .	Southampton,East Park	2·48	95	,, .	Buxton, Terrace Slopes	2·32	53
,, .	Ovington Rectory.......	1·60	59	*Ches* .	Bidston Obsy.............	4·33	141
,, .	Sherborne St. John......	1·42	59	*Lancs* .	Manchester, Whit. Pk.	2·54	74
Herts .	Royston,Therfield Rec.	1·56	61	,, .	Stonyhurst College......	3·97	78
Bucks .	Slough, Upton............	2·22	102	,, .	Southport, Bedford Pk.	3·90	112
Oxf .	Oxford, Radcliffe.........	3·61	158	,, .	Ulverston, Poaka Beck	3·05	57
N'hant	Wellingboro, Swanspool	4·16	175	,, .	Lancaster, Greg Obsy.	3·90	86
,, .	Oundle	2·22	...	,, .	Blackpool	3·90	109
Beds .	Woburn, Exptl. Farm...	2·83	123	*Yorks* .	Wath-upon-Dearne......	4·91	205
Cam .	Cambridge, Bot. Gdns.	...	...	,, .	Wakefield,Clarence Pk.	4·33	167
,, .	March.......................	1·20	50	,, .	Oughtershaw Hall.......	5·83	...
Essex .	Chelmsford,County Gdns	1·15	53	,, .	Wetherby, Ribston H..	3·60	132
,, .	Lexden Hill House......	1·66	...	,, .	Hull, Pearson Park......	2·84	98
Suff .	Haughley House.........	2·53	...	,, .	Holme-on-Spalding......	2·73	102
,, .	Rendlesham Hall........	1·46	73	,, .	Felixkirk, Mt. St. John.	2·74	96
,, .	Lowestoft Sec. School...	·53	24	,, .	York, Museum Gdns....	2·15	85
,, .	Bury St. Ed., WestleyH.	2·00	77	,, .	Pickering, Houndgate...	3·14	122
Norf. .	Wells, Holkham Hall...	1·07	45	,, .	Scarborough..............	2·95	106
Wilts .	Porton, W.D. Exp'l. Stn	1·77	79	,, .	Middlesbrough............	3·64	133
,, .	Bishops Cannings........	4·17	135	,, .	Baldersdale, Hury Res.	3·37	97
Dor .	Weymouth, Westham.	...	...	*Durh* .	Ushaw College............	1·69	58
,, .	Beaminster, East St....	2·43	78	*Nor* .	Newcastle, Leazes Pk...	2·08	74
,, .	Shaftesbury,Abbey Ho.	2·52	87	,, .	Bellingham, Highgreen	2·01	57
Devon .	Plymouth, The Hoe....	4·57	148	,, .	Lilburn Tower Gdns....	2·72	96
,, .	Holne, Church Pk. Cott.	8·46	189	*Cumb* .	Carlisle, Scaleby Hall...	2·78	68
,, .	Teignmouth, Den Gdns.	3·77	167	,, .	Borrowdale, Seathwaite	8·75	80
,, .	Cullompton	4·09	134	,, .	Thirlmere, Dale Head H.	5·39	70
,, .	Sidmouth, U.D.C........	3·74	...	,, .	Keswick, High Hill......	2·96	57
,, .	Barnstaple, N. Dev.Ath	7·38	224	,, .	Ravenglass, The Grove	3·51	77
,, .	Dartm'r,Cranmere Pool	7·90	...	*West* .	Appleby, Castle Bank...	2·15	65
,, .	Okehampton, Uplands.	7·01	165	*Mon* .	Abergavenny, Larchf'd	3·56	119
Corn .	Redruth, Trewirgie......	3·58	105	*Glam* .	Ystalyfera, Wern Ho....	6·56	106
,, .	Penzance, Morrab Gdns.	4·79	151	,, .	Treherbert, Tynywaun.	6·34	...
,, .	St. Austell, Trevarna...	5·36	148	,, .	Cardiff, Penylan..........	3·14	74
Soms .	Chewton Mendip.........	3·65	81	*Carm* .	Carmarthen,M. & P. Sch.	3·64	76
,, .	Long Ashton............	3·36	96	*Pemb* .	Pembroke,Stackpole Ct.	...	...
,, .	Street, Millfield..........	2·28	85	*Card* .	Aberystwyth	3·35	...
Glos .	Blockley	2·91	...	*Rad* .	BirmW.W.Tyrmynydd	3·68	68
,, .	Cirencester, Gwynfa....	4·48	149	*Mont* .	Newtown, Penarth Weir	...	...
Here .	Ross-on-Wye.............	2·81	110	,,	Lake Vyrnwy	4·71	91
Salop .	Church Stretton.........	3·43	106	*Flint* .	Sealand Aerodrome......	4·07	148
,, .	Shifnal, Hatton Grange	3·70	132	*Mer* .	Blaenau Festiniog	6·55	64
,, .	Cheswardine Hall........	3·34	101	,, .	Dolgelley, Bontddu......	5·88	104
Worc .	Malvern, Free Library...	3·87	134	*Carn* .	Llandudno	2·60	92
,, .	Ombersley, Holt Lock.	2·19	81	,, .	Snowdon, L. Llydaw 9..	7·75	...
War .	Alcester, Ragley Hall...	3·42	123	*Ang* .	Holyhead, Salt Island...	2·05	65
,, .	Birminghm, Edgbaston	3·29	121	,, .	Lligwy	1·15	...

Rainfall : August, 1938 : Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
I. Man	Douglas, Boro' Cem	2·17	57	*R&C*	Achnashellach	...	...
Guern.	St.Peter P't.Grange Rd.	2.28	97	,,	Stornoway, C.GuardStn.	4·52	120
Wig	Pt. William, Monreith.	3·01	78	*Suth*	Lairg	2·51	79
,,	New Luce School	2·72	61	,,	Skerray Borgie	...	...
Kirk	Dalry, Glendarroch	2·16	45	,,	Melvich	2·81	94
Dumf.	Eskdalemuir Obs	3·02	59	,,	Loch More, Achfary	5·75	98
Roxb	Hawick, Wolfelee	1.04	31	*Caith*	Wick	2·37	86
,,	Kelso, Broomlands	1.40	47	*Ork*	Deerness	2·48	86
Peeb	Stobo Castle	1·78	50	*Shet*	Lerwick Observatory	1·61	53
Berw	Marchmont House	3·06	92	*Cork*	Cork, University Coll	1·85	55
E.Lot	North Berwick Res	3·92	124	,,	Roches Point, C.G. Stn.	3·19	84
Midl	Edinburgh, Blackfd. H.	1·15	36	,,	Mallow, Longueville	2·57	83
Lan	Auchtyfardle	3·37	...	*Kerry.*	Valentia Observatory	5·62	117
Ayr	Kilmarnock, Kay Park	2·73	...	,,	Gearhameen	6·50	86
,,	Girvan, Pinmore	2·67	60	,,	Bally McElligott Rec	5·19	...
,,	Glen Afton, Ayr San.	4·09	76	,,	Darrynane Abbey	5·84	134
Renf	Glasgow, Queen's Park	4·17	118	*Wat*	Waterford, Gortmore	3·53	93
,,	Greenock, Prospect H.	2·48	48	*Tip*	Nenagh, Castle Lough.	5·29	134
Bute	Rothesay, Ardencraig	3·14	64	,,	Cashel, Ballinamona	2·90	83
,,	Dougarie Lodge	2·96	70	*Lim*	Foynes, Coolnanes	5·76	149
Arg	Loch Sunart, G'dale	4·92	86	*Clare*	Inagh, Mount Callan	8·30	...
,,	Ardgour House	6·52	...	*Wexf*	Gorey, Courtown Ho	2·27	68
,,	Glen Etive	6·12	81	*Wick*	Rathnew, Clonmannon.	2·06	...
,,	Oban	4·70	...	*Carl*	Bagnalstown, Fenagh H.	3·41	97
,,	Poltalloch	...	...	,,	Hacketstown Rectory	3·26	80
,,	Inveraray Castle	5·64	86	*Leix*	Blandsfort House	4·06	103
,,	Islay, Eallabus	3·70	85	*Offaly.*	Birr Castle	4·09	107
,,	Mull, Benmore	9·50	81	*Kild*	Straffan House	2·60	69
,,	Tiree	...	...	*Dublin*	Dublin, Phoenix Park	2·12	67
Kinr	Loch Leven Sluice	1·56	41	*Meath.*	Kells, Headfort	2·72	66
Fife	Leuchars Aerodrome	2·12	69	*W.M*	Moate, Coolatore	...	...
Perth	Loch Dhu	4·10	61	,,	Mullingar, Belvedere	2·39	57
,,	Crieff, Strathearn Hyd.	2·81	67	*Long*	Castle Forbes Gdns	3·70	90
,,	Blair Castle Gardens	2·39	71	*Gal*	Galway, Grammar Sch.	4·52	110
Angus.	Kettins School	1·74	48	,,	Ballynahinch Castle	6·35	116
,,	Pearsie House	1·33	...	,,	Ahascragh, Clonbrock.	4·55	109
,,	Montrose, Sunnyside	·65	23	*Rosc*	Strokestown, C'node	3·31	87
Aber	Balmoral Castle Gdns.	1·36	45	*Mayo.*	Blacksod Point	4·22	92
,,	Logie Coldstone Sch	1·91	60	,,	Mallaranny	6·92	...
,,	Aberdeen Observatory.	1·13	41	,,	Westport House	4·32	107
,,	New Deer School House	1·37	46	,,	Delphi Lodge	6·24	72
Moray	Gordon Castle	2·47	78	*Sligo*	Markree Castle	3·56	82
,,	Grantown-on-Spey	1·61	50	*Cavan.*	Crossdoney, Kevit Cas.	2·65	...
Nairn.	Nairn	1·33	55	*Ferm*	Crom Castle	2·22	54
Inv's	Ben Alder Lodge	2·32	...	*Arm*	Armagh Obsy	2·57	71
,,	Kingussie, The Birches.	1·67	...	*Down.*	Fofanny Reservoir	3·06	...
,,	Loch Ness, Foyers	1·97	64	,,	Seaforde	2·26	60
,,	Inverness, Culduthel R.	1·76	69	,,	Donaghadee, C. G. Stn.	1·87	56
,,	Loch Quoich, Loan	6·67	...	*Antr*	Belfast, Queen's Univ	2·77	75
,,	Glenquoich	6·91	84	,,	Aldergrove Aerodrome.	2·26	63
,,	Arisaig House	4·29	74	,,	Ballymena, Harryville.	3·18	74
,,	Glenleven, Corrour	4·44	81	*Lon*	Garvagh, Moneydig	2·33	...
,,	Fort William, Glasdrum	...	...	,,	Londonderry, Creggan.	3·01	65
,,	Skye, Dunvegan	4·77	...	*Tyr*	Omagh, Edenfel	2·52	59
,,	Barra, Skallary	3·72	...	*Don*	Malin Head	2·65	63
R&C.	Tain, Ardlarach	1·24	43	,,	Dunfanaghy	2·27	61
,,	Ullapool	3·67	103	,,	Dunkineely	4·18	...

Erratum : Galway Grammar School, July, *for* 4·68/146 *read* 4·78/149.

Climatological Table for the British Empire, March, 1938

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean							
	Mean of Day M.S.L.	Diff. from Normal.	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.			Am'nt.	Diff. from Normal.	Days	Hours per day.	Per-cent-age of possi-ble.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy....	1025·1	+11·7	65	31	58·3	40·3	49·3	+ 6·2	45·1	88	6·2	0·26	− 1·43	3	5·6	47
Gibraltar....................	1023·0	+ 5·9	65	49	58·9	53·0	55·9	− 1·7	51·2	78	6·0	2·71	...	3	...	...
Malta........................	1022·9	+ 8·7	66	44	58·6	49·2	53·9	− 3·2	49·3	77	4·2	1·99	+ 0·51	8	8·5	71
St. Helena	1014·7	− 1·4	72	58	69·3	62·1	65·7	+ 0·6	63·1	91	9·5	3·24	− 0·78	17	...	...
Freetown, Sierra Leone	1009·9	+ 0·9	92	72	88·4	74·7	81·5	...	75·2	73	4·0	0·09	− 1·07	2	...	...
Lagos, Nigeria	1008·5	− 0·4	92	72	89·3	76·8	83·1	− 0·3	77·1	85	4·8	1·66	− 2·09	7	6·0	50
Kaduna, Nigeria	1009·6	...	102	59	94·5	67·3	80·9	− 0·2	63·2	47	4·1	0·06	− 0·48	1	8·7	73
Zomba, Nyasaland	1009·5	− 0·1	87	50	78·1	63·2	70·7	− 0·6	68·6	86	7·4	12·68	+ 3·60	20	...	...
Salisbury, Rhodesia...	1011·3	− 0·8	82	50	77·6	56·2	66·9	− 1·3	60·8	73	4·5	3·37	...	11	8·5	70
Cape Town	1014·2	− 0·3	91	52	78·5	59·3	68·9	+ 0·8	61·5	81	4·0	0·65	− 0·23	8	...	...
Johannesburg	1011·7	− 0·1	83	49	77·5	55·3	66·4	+ 3·0	56·6	66	2·0	1·75	− 2·69	9	8·6	70
Mauritius	1009·5	− 2·4	88	68	84·6	73·6	79·1	+ 1·1	75·2	77	5·9	6·37	− 2·22	20	8·5	70
Calcutta, Alipore Obsy.	1006·7	− 3·2	101	62	96·4	73·4	84·9	+ 4·7	74·4	86	2·4	0·52	− 0·86	2*	...	...
Bombay	1008·6	− 2·3	91	70	86·9	73·5	80·2	+ 0·7	72·3	76	1·4	0·00	− 0·02	0*	...	...
Madras	1008·5	− 2·4	95	67	89·9	74·3	82·1	+ 1·0	76·1	81	3·9	1·45	+ 1·11	1*	...	...
Colombo, Ceylon	1008·8	− 1·3	89	70	86·6	74·8	80·7	− 1·1	77·0	77	6·8	8·14	+ 3·86	16	6·9	57
Singapore	1008·6	− 1·1	91	73	85·6	75·1	80·3	− 0·9	77·0	80	7·8	7·60	+ 0·20	16	4·2	35
Hongkong................	1014·8	− 1·2	83	47	68·0	59·5	63·7	+ 0·4	59·7	79	8·5	5·75	+ 2·81	14	2·7	22
Sandakan	1009·0	...	89	73	86·1	75·4	80·7	− 0·3	76·9	86	7·4	9·24	+ 0·77	16	...	...
Sydney, N.S.W..........	1014·6	− 1·7	94	55	77·9	64·6	71·3	+ 2·0	65·9	68	5·0	1·32	− 3·66	7	6·6	54
Melbourne	1016·0	− 0·9	97	48	75·3	56·2	65·7	+ 1·2	53·8	40	6·9	1·16	− 1·02	8	5·7	46
Adelaide	1017·6	+ 0·5	103	49	82·4	59·9	71·1	+ 1·2	60·5	49	5·1	0·13	− 0·89	5	8·0	66
Perth, W. Australia ...	1015·9	+ 0·6	98	51	79·6	61·1	70·3	− 0·9	61·0	56	6·2	1·75	+ 0·94	8	8·2	67
Coolgardie	1015·1	+ 0·2	98	52	86·4	61·1	73·7	+ 1·8	62·3	62	4·5	0·60	− 0·34	2	...	...
Brisbane..................	1014·0	− 0·4	91	60	83·3	67·1	75·2	+ 0·9	69·1	72	5·9	4·24	− 1·53	15	7·2	58
Hobart, Tasmania......	1015·1	+ 0·9	81	44	67·2	51·6	59·4	+ 0·1	53·7	67	6·8	4·66	+ 2·96	12	5·9	48
Wellington, N.Z.	1020·1	+ 2·9	78	47	69·9	57·8	63·9	+ 3·3	60·5	78	7·3	0·95	− 2·38	10	6·4	52
Suva, Fiji	1010·0	+ 1·6	92	71	85·9	74·5	80·2	+ 0·1	74·8	80	5·4	8·54	− 5·95	25	5·8	48
Apia, Samoa	1009·7	+ 0·5	87	71	85·6	74·2	79·9	+ 0·6	75·9	76	6·1	10·80	− 3·18	14	6·0	49
Kingston, Jamaica	1015·2	+ 0·3	89	65	85·3	67·8	76·5	− 0·6	65·6	79	1·4	0·75	− 0·27	5	6·4	53
Grenada, W.I.	1011·1	− 1·9	89	70	86	73	79·5	+ 1·7	75	79	6	4·18	+ 1·52	17	...	...
Toronto...................	1014·1	− 3·2	73	− 5	44·1	27·4	35·7	+ 6·1	...	...	6·5	1·64	− 0·77	17	4·2	35
Winnipeg	1010·9	− 8·3	66	−12	38·2	18·2	28·2	+13·2	...	...	4·3	0·50	− 0·66	4	5·5	46
St. John, N.B.	1014·9	+ 0·8	49	− 7	34·8	19·3	27·1	− 1·3	21·8	75	6·3	4·49	− 0·05	16	5·5	46
Victoria, B.C...........	1011·4	− 4·5	57	32	50·3	38·9	44·6	+ 1·1	41·9	81	7·4	2·62	+ 0·19	20	4·9	41

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

Frontispiece

[Photo: W. G. Busbridge

N. K. Johnson, M.Sc., A.R.C.S.

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MR. N. K. JOHNSON

Following upon the retirement of Sir George Simpson, Mr. N. K. Johnson, M.Sc., A.R.C.S., took up his duties as Director of the Meteorological Office on September 3rd, 1938.

Mr. Johnson, who is a native of Canterbury, received his scientific training at the Royal College of Science, South Kensington. After taking his Honours Degree in Physics he remained at the College for a short while as Assistant Demonstrator and also carried out research work in astrophysics under Professor A. Fowler, F.R.S. In 1913 he became assistant to Sir Norman Lockyer and Dr. W. J. S. Lockyer at the Hill Observatory, Sidmouth, a post which he relinquished for service in the Royal Air Force during the war. After the war he was appointed Professional Assistant in the Meteorological Office and was posted to Shoeburyness. Here, in addition to his routine duties, he found time for much useful research work and published several papers including "A comparison of the anemometer records for Shoeburyness and the Maplin Lighthouse" (M.O. *Prof. Notes* No. 28) and "The behaviour of pilot balloons at great heights" (*Quart. J. R. met. Soc.*, **48**, pp. 49–59). In 1921 a meteorological section was established at the War Department Experimental Station, Porton, and Mr. Johnson was seconded to the War Office to take charge. This position afforded great scope for an officer possessing a natural inclination towards experimental research work and he tackled the difficult problems which confronted him with great success. Much of this work was of a secret nature, but he published a number of papers, including the well known Geophysical Memoir (No. 46) on "A study of the vertical gradient of temperature in the atmosphere near the ground." For this work he designed an entirely original system for recording differences of temperature over short vertical distances, in which use was made of continuously aspirated electrical resistance thermometers and a multiple thread recorder. By this means the thermal structure of the lower layers of the atmosphere was fully revealed and studied for the first time. Other papers included " The measurement of the lapse rate of temperature by an optical method " (with O. F. T. Roberts) (*Quart. J. R. met. Soc.*, **51**, pp. 131–138), "Some measurements of temperatures near the surface in various kinds of soils " (with E. L. Davies) (*Quart. J. R. met. Soc.*, **53**, pp. 45–59) and " Atmospheric oscillations shown by the microbarograph " (*Quart. J. R. met. Soc.*, **55**, pp. 19–30).

In 1928 the post of Director of Experiments at Porton fell vacant and Mr. Johnson received the appointment, thus terminating for a time his attachment to the Meteorological Office. Later he received further promotion to the post of Chief Superintendent of the Chemical Defence Research Department, War Office.

Mr. Johnson brings to his new appointment a high reputation as an investigator of meteorological problems, combined with wide experience as an administrator of a scientific department concerned with service questions. All readers of the Magazine will join us in wishing him success as Director of the Meteorological Office.

Sunshine Records at Health Resorts

In an article entitled " The ' sunshine race ' : an exposure " which appeared on August 21st, the Meteorological Correspondent of *The Observer* drew attention to the fact that the cards used for recording sunshine could be manipulated in various ways so as to increase the apparent duration of sunshine. The article went on to state that it was known for certain that this nefarious practice was adopted at some of the coast towns in southern and eastern England.

This article gave rise to much comment and a letter on the subject was addressed by Dr. A. Cox, Secretary of the British Health Resorts Association, to the Superintendent of the British Climatology Division, Meteorological Office. The following reply was sent :

Dear Dr. Cox,

Your letter of August 23rd has been sent on to me here, where I am on leave until September 12th.

It is of course *possible* to falsify any sort of instrumental record, but it is not at all easy to produce a false sunshine record which would deceive an expert. Every health resort in association with the Meteorological Office has to send up its sunshine cards for scrutiny at the end of every month. The cards are examined by staff experienced in the work, and any case of apparent falsification is brought to my personal notice. Having regard to the large number of co-operating stations, cases of the sort are infrequent, and I can assure you that they are dealt with promptly and effectively.

With these safeguards, I think it may reasonably be claimed that the sunshine records from co-operating health resorts form a reliable body of statistics, and they are accepted as such for official purposes.

Yours sincerely,

E. G. Bilham.

Froxfield, Hants, August 27th, 1938.

The substance of this reply was included in a letter dated August 30th sent by Dr. Cox to the Editor of *The Observer.* Dr. Cox's letter has not been published and we therefore take the present opportunity to correct the unfortunate impression which may have been created by the article in *The Observer.*

Readers of this Magazine are aware of the fact that the health resorts provide a large proportion of the official climatological data of this country, and that they do so voluntarily and efficiently. Moreover, a charge against the bona fides of the health resorts involves also a charge—of negligence at least—against the Director of the Meteorological Office by whose authority the data are communicated to the Press and included in official publications.

It is surprising and unfortunate that so responsible a newspaper as *The Observer* should not only have given publicity to this charge without further enquiry as to the facts, but should then have closed its columns to Dr. Cox. The Secretary of the Association, which works in close co-operation with the Meteorological Office and with influential medical bodies for the purpose of promulgating reliable information about British spas and health resorts, was surely entitled to a hearing.

Wave Motion in the Upper Air

By G. A. Bull, B.Sc.

On November 16th, 1936, a pronounced wave-like variation of wind was observed over southern Scotland. Special interest attaches to this occasion because pilot balloons were sent up at frequent intervals from Abbotsinch during the occurrence there of the waves. The ascents were made using the tail method, so as to obtain information about the vertical as well as the horizontal motion of the atmosphere. The results of these ascents were given by R. T. Andrews in the *Meteorological Magazine* of August, 1937. The present note is an extension of the one by Andrews and summarizes the results of a theoretical investigation, using the hydrodynamical theory of wave motion.

It is assumed, in the first place, that the waves were due to the oscillations of a roughly horizontal surface of discontinuity. Reasons for believing this to be true will appear later. The theory of such oscillations is given, with applications to several special cases, in a paper by Dr. Goldie entitled, " Waves at an approximately horizontal surface of discontinuity in the atmosphere " (*Quart. J. R. met. Soc.,*

51, pp. 239–246). The general theory is, of course, given in all the text-books of hydrodynamics.

The first result of the theory is that the wind should give wavy speed and direction traces on the anemogram. A glance at the Abbotsinch anemogram reproduced as the frontispiece to the August, 1937, number of this Magazine, shows this to be the case. If the oscillations had been due to convectional cells, the wind variations would have been saw-toothed in shape showing a very rapid rise to a maximum, and then a gradual dying away.

The second result is that the pressure should show a wave-like variation of the same periodicity as the wind, and either exactly in the same phase as, or exactly in the opposite phase to, the wind variations. That is, to a wind maximum should correspond exactly a pressure maximum, or exactly a pressure minimum. There is no barograph at Abbotsinch sufficiently sensitive to show the small variations in pressure but there are two such barographs at Eskdalemuir and both of these and the Eskdalemuir anemogram (Fig. 1) show the oscillations. At Eskdalemuir the pressure oscillations were of the same periodicity as the wind oscillations and were almost exactly in opposite phase. Pressure minima or maxima occurred within four minutes of the corresponding wind maxima, with a wave period of twenty minutes. In many cases agreement is exact so far as can be judged from the records. The period of the Eskdalemuir variations agrees with those at Abbotsinch and the amplitudes were about the same.

Given the amplitudes and periods of the simultaneous pressure and wind waves at the same place, it is possible to calculate the velocity and direction of motion of the waves and derive an upper limit to the height of the waved surface of discontinuity. The Eskdalemuir data give a wave velocity of 6 mi./hr. from WNW and an upper limit of 4,000 feet for the height of the surface of discontinuity. In this connection, it is worth noting that a record of upper air temperature obtained over Mildenhall at 0700 G.M.T. showed an inversion between 3,000 and 4,000 feet. The air above this inversion was much drier (relative humidity 40 per cent.), suggesting that subsidence in the wedge of high pressure, which extended from south to north over the British Isles, was responsible for the inversion. It seems likely, therefore, that the oscillations took place on this inversion, although there are no direct observations of it nearer than Mildenhall. Since there are no pressure data from Abbotsinch all that can be said is that the waves there were moving from either WNW or ESE, as an examination of the anemogram shows that the variable wind due to the oscillation, and added to the mean wind, blew from these two directions alternately. The result obtained from the Eskdalemuir data, of course, strongly suggests that the waves over Abbotsinch were moving from WNW.

We can now turn to the vertical velocities shown by the Abbotsinch pilot balloon observations.

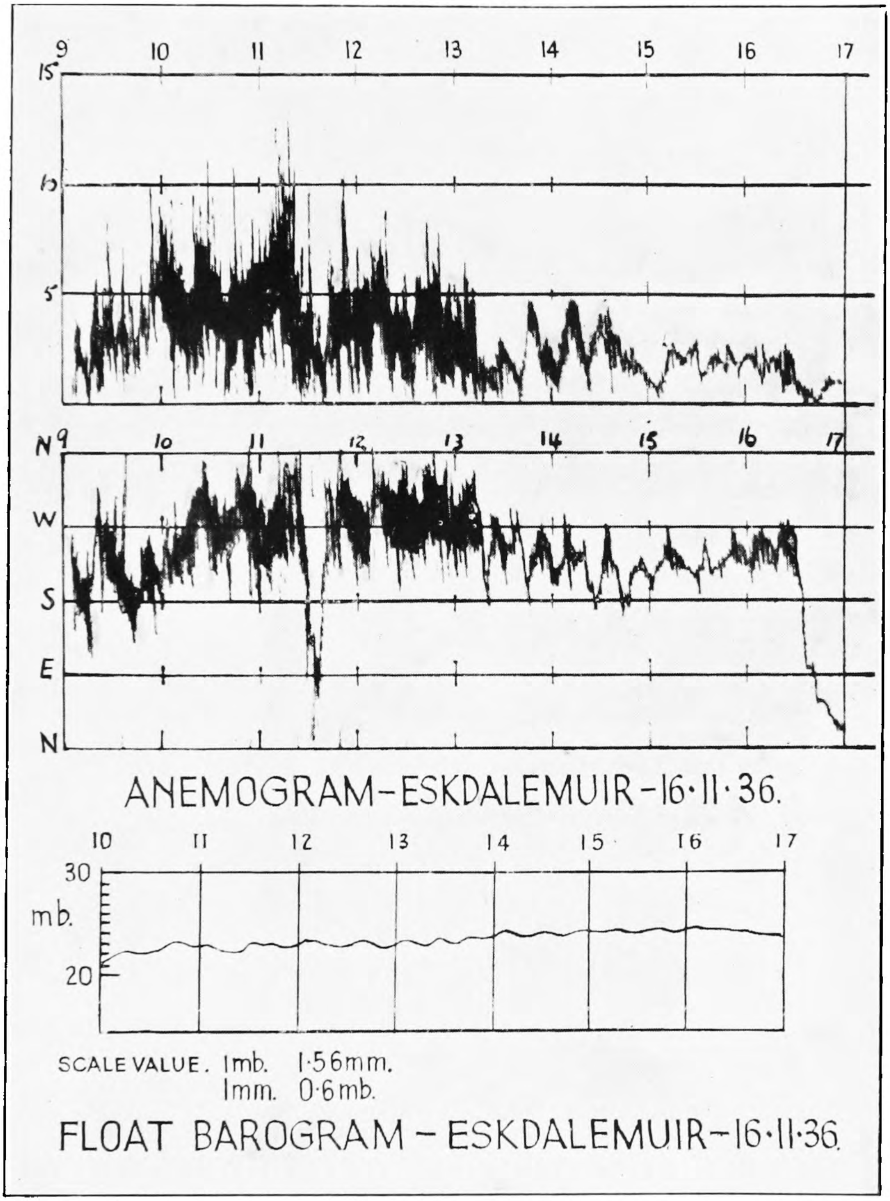
9 10 11 12 13 14 15 16 17
15
10
5
N 9 10 11 12 13 14 15 16 17
W
S
E
N
ANEMOGRAM-ESKDALEMUIR-16·11·36.
10 11 12 13 14 15 16 17
30
mb.
20
SCALE VALUE. 1mb. 1·56mm.
1mm. 0·6mb.
FLOAT BAROGRAM-ESKDALEMUIR-16·11·36.

FIG. 1.

All that the theory has, qualitatively, to say about the connection between the waved surface, the vertical currents and the surface pressure changes, is given in the diagram (Fig. 2). The waves are supposed to be moving from left to right with velocity V. Maxima of pressure at the ground occur beneath crests, and minima beneath troughs of the waved surface. The air ascends beneath the forward half of the wave, and descends beneath the rearward half. The connection between the wind changes at the ground is more complicated. The wind waves are in phase with the waves on the surface of discontinuity, if the quantity V-U, where U is the component of the mean wind in the direction of the waves, is positive, and are in opposite phase if V–U is negative. At Eskdalemuir V–U was negative as the opposition in phase of the pressure and wind waves shows at once, since the pressure waves are in phase with the waves of the waved surface.

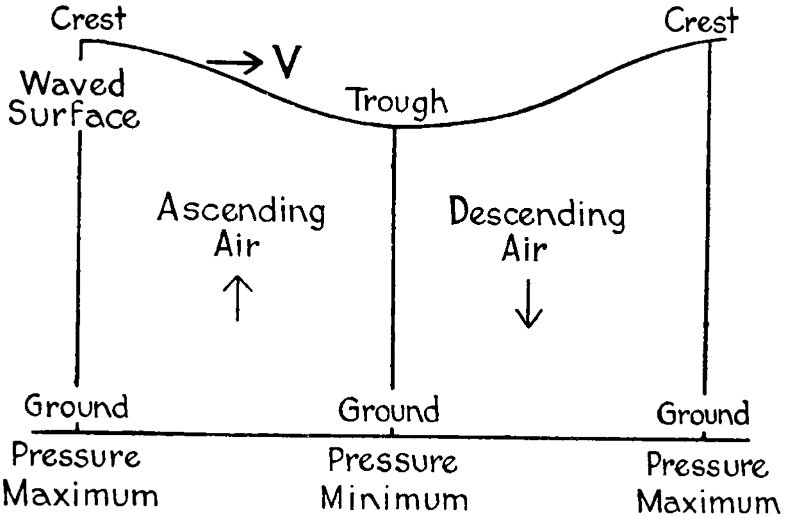

FIG. 2.—VERTICAL MOTION AND PRESSURE CHANGES UNDER WAVED SURFACE.

We can now consider what sort of vertical currents pilot balloons should register when released at crests and troughs of the wind waves. The following table gives all the possibilities.

Notation.	V	Velocity of waves.
	U	Component of mean wind from left to right parallel to direction of wave motion.
	U′	Maximum value of added wind due to wave motion.
	|V|	Numerical value of V irrespective of sign.

Case I

V and U same sign (taken as positive).

V greater than U (wind and pressure waves in phase).

(*a*) Balloon released at wind crest.
Balloon enters rising air at first if $U + U' > V$. Possible.
Balloon enters descending air at first if $U + U' < V$. Possible.

(*b*) Balloon released at wind trough.
Balloon enters rising air at first if $V > (U - U')$. Possible.
Balloon enters descending air at first if $V < (U - U')$. Not possible.

Case II

V less than U (wind and pressure waves in opposite phase).

(*a*) Balloon released at wind crest.
Balloon enters rising air at first if $V > (U + U')$. Not possible.
Balloon enters descending air at first if $V < (U + U')$. Possible.

(*b*) Balloon released at wind trough.
Balloon enters rising air at first if $V < (U - U')$. Possible.
Balloon enters descending air at first if $V > (U - U')$. Possible.

Case III

V and U of opposite signs (wind and pressure waves in opposite phase).

(*a*) Balloon released at wind crest.
Balloon enters rising air at first if $|V| > (U + U')$. Possible.
Balloon enters descending air at first if $|V| < (U + U')$. Possible.

(*b*) Balloon released at wind trough.
Balloon enters rising air at first if $|V| > (U - U')$. Possible.
Balloon enters descending air at first if $|V| < (U - U')$. Possible.

If the waves were of the same speed and direction at Abbotsinch as at Eskdalemuir (6 mi./hr. from WNW.) then since the wind velocity at the crests in that direction was greater than the wave velocity, balloons released at crests should show a descending motion of the air in the lower layers. The wind velocity near the ground at troughs in the direction of wave motion was rather less than that of the waves so that balloons released at troughs should also show descending air motion.

Actually, all the balloons released at crests registered, with one slight exception, definite rising motion while all those released at troughs showed descending motion. The facts concerning these vertical currents are detailed in Table II of Andrews' paper. The behaviour of the balloons released at troughs agrees with the theory but the behaviour of the others does not. Possible explanations of this are (1) that the wave speed and direction and so the connection between the phases of wind and pressure waves were different at Abbotsinch from what they were at Eskdalemuir, (2) that the arrangement of vertical currents is greatly distorted by friction near the ground. Owing to the absence of a sensitive barograph at Abbotsinch (1) cannot be tested. The waves there were certainly coming from either WNW or ESE and the former direction seems much the more likely in view of the wind direction in the upper air and the Eskdalemuir data. The second possibility is also difficult to test.

There is a simple relation between the time spent and distance covered by a balloon in the free air in either a descending or ascending current and the wave-velocity and period. Suppose that the wind has a component in the direction of motion of the waves which is greater than the wave-velocity. Then if D is the distance travelled by the balloon in the direction of wave-motion in the time t spent in either an ascending or descending current, and λ is the wave-length and V the wave-velocity, then $D = Vt + \lambda/2$ which may be written $D = V(t + \frac{T}{2})$ where T is the wave period. D and t can be taken from the pilot balloon sheets and T from the anemogram. Inserting numerical values for various ascending and descending currents recorded by the balloons in the free air, values for V are obtained ranging from 3 to 6 mi./hr. These values are in good agreement with the value of 6 mi./hr. obtained from the wind and pressure records at Eskdalemuir.

According to theory the magnitude of the vertical currents should increase rapidly with height in the lower layer and then decrease again in the upper layer. The results show an increase with height in the first 2,000 to 3,000 feet but there is not much evidence of a decrease at higher levels. No balloon recorded a vertical current greater than 120 ft./min. (1⅓ mi./hr.) in the lowest 600 feet. Out of 89 observations of vertical currents, 59 (irrespective of sign) are less than 300 ft./min. (3 mi./hr.). One value is 900 ft./min. (10 mi./hr.) but that is quite exceptional.

The theory thus accounts for the observed occurrences, with the exception of the kind of rising current recorded by those balloons released at crests of wind waves. The most likely explanation of this seems to lie in a distortion of the boundaries between rising and falling currents near the ground.

A puzzling occurrence at Abbotsinch is the existence of fluctuations in relative humidity as shown by the hygrograph in the screen. These fluctuations are superposed on the ordinary diurnal range, and agree closely with the wind variations. As the wind rose so did the relative humidity, and as it fell so did humidity. The range was only 3 to 4 per cent. No variations are shown on the thermograph. If the variations in relative humidity were reflections of temperature changes, then the latter should have had a range of 1° to 2° F., which should easily have been registered by the thermograph. It is possible that the difference in ventilation of the hairs with the changing wind speed accounts for this phenomenon.

Correspondence

To the Editor, *Meteorological Magazine*

Symons's Thunderstorm Survey of 1858

After reading the first two articles in the *Meteorological Magazine* of August, 1938, it is interesting to note that "Thunderstorms and Accidents from Lightning in 1858" was put on record in a manuscript * of 25 pages neatly written by G. J. Symons at the age of twenty for reading before the British Association.

In an opening paragraph we find : "The following report has been compiled from private information furnished by the gentlemen named on the preceding page, and one or two other sources ; material aid as to the localities visited has also been derived from the returns of the British Meteorological Society.

Newspaper reports are never inserted until they have been personally verified."

In 1858 Symons received reports of thunderstorms, thunder or lightning on 118 days from 727 stations ; on 21 days in June alone 194 stations reported the phenomena.

The resulting casualties during the year included 7 men killed, 25 men and women injured, 28 horses, 2 cows and 43 sheep killed, 27 buildings and 1 railway train struck.

R. M. POULTER.

Meteorological Office, South Farnborough, Hants, 9th September, 1938.

The West of England Thunderstorm of August 4th, 1938

Mr. Douglas in his valuable article in the September number, very rightly refers to the west country thunderstorm of August 4th as a prominent landmark in the meteorological history of the south-west of England. During the last few weeks I have met or heard from a number of people who experienced the storm in various parts of Devon and Cornwall, and they all lay stress not only on the intensity of rain and hail but also on the truly terrible character of the thunder and lightning which after a duration of eleven hours not unnaturally caused consternation here and there among country people and fishing folk. Thunder is less frequent in the south-western counties than in midland, eastern and northern England, but I do not think it is realized how prone Devon and Cornwall are to a type of thunderstorm which, developing at night, is for violence and duration probably the most impressive and spectacular that we experience in Britain. I could quote many instances of the kind.

L. C. W. BONACINA.

13, Christchurch Hill, Hampstead, N.W.3, September 30th, 1938.

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* In the files of the Meteorological Office, South Farnborough.

The Prediction of Minimum Temperature on Clear Days at Selected Stations in India

The reprint of a paper with the above heading by Mr. Narasimhan and the present writer (reprinted from the *Indian Journal of Agricultural Science*, VII, part 5, October, 1937) was reviewed in the *Meteorological Magazine* for August, 1938 (pp 182–184). Table IV of our paper had been printed *correctly* in the original journal, but, strangely enough, at the reprint stage certain misprints crept in, which were unfortunately unnoticed by us. The misprints relate to some of the values of b_v in the regression equations expressing the minimum temperature as a function of the maximum temperature X and the vapour pressure V of the previous afternoon (i.e. $N = b_x X + b_v V +$ Constant, where b_x and b_v are constants for each station). The errata are given below—

Station	Value of b_v	
	For	*Read*
Bombay	38·12	8·12
Poona	4·71	34·71
Hyderabad ... ... Deccan	3·70	13·70
Bangalore	3·46	23·46
Madura	5·16	15·16
Madras	4·93	24·93
Vizagapatam	8·88	28·88
Jacobabad	6·22	16·22

When the *correct* values of b_v are examined it will be seen that the variability from station to station is not quite so large as is shown by the *incorrect* values. The mean value of b_v is of the order of 23 ; twelve out of the nineteen values lie between 21 and 37, five between 13 and 18 and only two between 8 and 12. This takes away some of the force of the reviewer's criticism of the statistical results discussed in the paper. Such results do serve to summarise the relevant climatological information in a useful manner and to indicate how far they may be of use for practical purposes like forecasting. It was, of course, not intended to use the statistical results for verifying radiation theory.

The relative merits of Ångström's formula $\left(\frac{S}{\sigma T^4} = A - B \times 10^{-\gamma e}\right)$ and Brunt's expression $\left(\frac{S}{\sigma T^4} = a + b\sqrt{e}\right)$ have been referred to in the review. A discussion on the subject will be found in a paper by Raman (*Proc. Ind. Acad. Sc.*, **1**, 11, pp. 815–821, 1935) and in another by Ramanathan and the present writer (*Proc. Ind. Acad. Sc.*, **1**, 11, pp. 822–829, 1935). In the first paper it was shown by actual computations that Brunt's expression should be considered as an approximation of Ångström's formula for values of vapour pressure ranging from 2 to 30 mb. In the latter paper, using Weber and Randall's latest measurements (*Phys. Rev.*, **40**, p. 385, 1932), we showed that the values of the absorption coefficient of water vapour used by earlier workers (from Hettner's measurements) were too high in the region 10·5 — 15μ. With the help of the revised values the physical basis for Ångström's formula was also indicated.

I may point out that we have fully realised the modifying influence of feeble turbulence (which is seldom entirely absent during night) on nocturnal cooling and, as mentioned at the end of Part I of our paper, experimental work on the subject is actually in progress.

L. A. RAMDAS.

Poona 5, September 8th, 1938.

The Sound of Lightning

On August 19th, 1938, a thunderstorm occurred in the vicinity of the Royal Observatory, Hong Kong. There had been several flashes followed by claps and rolls, and the interval suggested a distance of half to two miles. Quite suddenly there was a flash accompanied by a sound similar to the blowing of a fuse or the tearing of a small piece of silk. The sound lasted perhaps a quarter of a second and was simultaneous with the flash or followed it immediately. The thunder clap came quite two seconds later. The phenomenon was observed by both of us, and also by the lady stenographer, all in different parts of the building.

The "swishing" sound of lightning has been discussed by C. J. P. Cave in the *Meteorological Magazine* for July, 1934. When he noted the phenomenon the lightning, swish and thunder were practically simultaneous, and the interesting point about the present observation is that there was a very definite interval between the swish and the thunder. If the clap of thunder was the sound caused by the lightning flash as it reached the ground, the interval between flash and clap would indicate that the lightning struck at a distance of about 2,000 feet from the Observatory. If this were the case, it would be difficult to account for the swish. Our impression is that the lightning struck the typhoon signal mast, a steel structure 150 feet high standing a few yards from the building, and that the thunderclap was immediately overhead. (The height of the cloud base at the time was estimated at 2,000–2,500 feet.) If the swish were due to the strike, and the thunderclap two seconds later to the discharge in the clouds, as the respective distances seem to indicate, how can the interval of silence between the swish and the clap be accounted for ?

G. S. P. HEYWOOD.
L. STARBUCK.

Royal Observatory, Hong Kong, August 20th, 1938.

Elliptical Solar Halo at Leuchars, May 30th, 1938

A very brilliant solar halo was observed at Leuchars on May 30th, 1938, lasting from 08h. to 15h. G.M.T. Angular measurements were obtained by means of a theodolite and from these measurements it was apparent that the halo was elliptical. At 9h. 15m., measurements gave the sun's elevation as 43° and azimuth 119°. The minor axis was found to subtend an angle of 44° and the major axis, parallel to the horizon, 64°, when the top of the halo had an elevation of 65° and the azimuths of the ends of the major axis 87° and 151°.

A very brilliant arc of upper contact, with ends bent downwards, and an almost complete mock sun ring were seen. Brilliant mock suns were formed at the intersection of the arc of contact and the mock sun ring (each 40° from the sun) and less intense mock suns at points 124° from the sun on the mock sun ring. The mock sun ring which did not extend to the elliptical halo or pass through the sun, had an elevation of 43° in all directions. The mock sun at 355° was considerably more brilliant than the one at 243° but not quite so brilliant as those 40° from the sun. The most brilliant points of the phenomenon were the highest and lowest extremities of the 22° halo and the mock suns 40° from the sun. These points were coloured faintly, red being nearest the sun in each case, while there was a diffused white glow between the arc of contact and the halo.

By 9h. 30m., the mock sun ring and the arc of contact had disappeared and only the halo of 22° was visible, lasting very faintly until 15h. During the period the sky was covered with 5/10 to 9/10 of cirro-stratus with small amounts of large cumulus and the wind, which was calm at first, became westerly gradually increasing to force 5.

On November 16th, 1931 (see *Meteorological Magazine*, Vol. 66. 1931, p. 290)* a somewhat similar halo was observed here and it was remarked then that it was probably only a coincidence that the 18th was the wettest November day recorded at Leuchars. In the present case we had 25 mm. of rain in the 48 hours beginning at 15h. on the 31st.

G. Froude.
J. R. Sandison.

Meteorological Office, Leuchars, Fife, May 30th, 1938.

Unusual Solar Haloes

My wife reports that yesterday afternoon from 2h. 45m. to 4h. 30m. (B.S.T.) a coloured solar halo was visible from the garden here, but was oval (not elliptic) instead of circular. We have seen some half dozen solar haloes recently, some coloured, some not, so she is familiar with their usual appearance, and of course lunar haloes are also familiar to her. I was unfortunately away from home all the afternoon and the halo was no longer visible on my return at 5h. 30m.

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* *See also* article on page 172 of the August issue of this Magazine.

The upper half of the halo was semicircular as usual, but the lower half suggested that it was being slightly pulled down at the lowest point, thus giving the lower half a semi-elliptical outline. The colour was faint but unmistakable, the inner part of the halo being tinged with red all round.

During the time she saw it my wife viewed it from various parts of the garden at different times to remove the possibility of optical illusion ; but the (literally) oval shape was constant. I am quite at a loss to account for this and shall be glad to hear whether such an occurrence has been noted before. I may add that the sky exhibited the hazy look characteristic of halo conditions and small feathery wisps of dark cloud crossed it pretty frequently, carried by the north-west wind from right to left.

The only suggestion I can make is that this remarkable phenomenon was caused in some way by refraction. But how ?

C. NICHOLSON.

Tresillian, Truro, Cornwall, September 6th, 1938.

A 23½° halo was visible here on September 2nd from 9h. to 14h. G.M.T., devoid of any trimmings ; especially perfect from 11h. 45m. to 13h. 30m. On a cloudless blue sky at 8h. a very lofty, thin haze first developed from W to NNW covering the sky by 9h. except for a low arch from E by N to SSW. The sky below was so free of haze that twenty miles of the Mendips, visible from the village here, stood out clearly, stretching from NE to NW, the summits closest to us west of Wells strikingly so, though ten miles away.

The very homogeneous haze was denser by 11h. 45m. but still so translucent that it was painful to look at the sun without dark glasses. Yet the area inside the halo looked very dark, especially compared with that outside, right up to the sun.

The halo itself was sharply defined, with colours from red to greenish blue. About 12h. 30m. lofty cumuli formed in fairly opaque patches, darkening the sun or obscuring parts of the halo. An hour or so later an arch of blue sky began to rise from W to WNW and the haze above it to thin out. It disappeared at about 14h., the cumuli following suit, giving a glorious late afternoon.

J. EDMUND CLARK.

Burleigh Redroofs, Street.

Snow in July, 1938

The Rev. E. F. Robson asks us to point out that his letter of August 3rd, published on page 208 of the September issue of this Magazine, should have referred to snow on July 9th, 1938, and not on June 9th.

Height calculations ; a simple method

I sometimes find I want to know the approximate height to which an observation of pressure and temperature in the upper atmosphere refers. I have discovered that I can get it with fair approximation from the tephigram by the following simple rule :—

> " Take the difference between the *potential* temperature and the actual temperature (in degrees F). Multiply by 2 and subtract 10 per cent. from the result. This gives the value of the height above the 1,000 mb. level in 100's of feet. The potential temperature is read very easily from the diagram.
>
> *Examples :*
>
> 1. Pressure 500 mb., Temperature − 7° F. Potential Temperature 92·5°. Difference 99·5°. Height 17,900 feet.
> 2. Pressure 637 mb., Temperature 13° F. Potential Temperature 78°. Difference 65°. Height 11,700 feet.
>
> If the surface pressure is greater than 1,000 mb. add 0·3 times the excess = 0·3 × (P − 1,000) and vice versa if it is less than 1,000 mb., e.g. surface pressure 1,017 mb., add 0·3×17=5, i.e., 500 feet to the value obtained as above."

The error in the height obtained in this way is usually not more than 100 feet for heights up to 20,000 feet. For example the true height of the 400 mb. level in Table I of Mr. E. G. Bilham's Professional Note No. 80 is given as 23,560 feet : the height computed in the simple manner described is 23,440 feet.

E. GOLD.

Meteorological Office, London, August 10th, 1938.

The Great Gale of June 1, 1938

It may be worth putting on record the extraordinary change in the colour of the blasted foliage ; for many miles the hedgerows of thorn were black, the sycamores and planes were a hideous dirty yellowy clay colour, other trees reddish brown. The effect was most striking as we coached many miles along the Dorset coast in early June.

Wasn't this the action of the salt upon the leaves rather than the mechanical action of buffeting suggested by the Editor ?

EDITH E. WILDE.

Milesdown, Winchester, August 24th, 1938.

[Mr. Norman E. Neville, of Fareham, has sent a sample leaf taken from a chestnut, very low on the tree, which shows marked discolouration on the edges and on lines running inwards parallel with the veins.

It would be interesting to hear from any inland observer who noticed an actual deposit of salt on foliage or other objects after this gale.—EDITOR.]

Experiments with No-lift Balloons

I read Mr. Mirrlees' article on experiments with no-lift balloons in your issue for September with considerable interest as many years ago I endeavoured to obtain information on surface turbulence by this means. I had to abandon the method owing to the great difficulty experienced in maintaining a true no-lift condition with the balloons used. If a day was one of broken sunshine, as soon as the sun came from behind a cloud the balloon would warm up and start rising at a considerable rate ; even on overcast days there seemed great difficulty in maintaining equilibrium between the balloon and the surrounding air. If it be assumed that the resistance to the movement of the balloon through the air varies as the square of the velocity it is apparent that a very small driving force will cause the balloon to move at quite an appreciable rate, and I calculate that a 10° F. rise of temperature of the gas in the balloon will give a rate of ascent of between 1 and 2 feet per second to a balloon which is in equilibrium when the temperature of the gas equals that of the air. As the balloon is subject to little or no ventilation, solar heating may easily raise its temperature by 10° or more and the disturbing effect of intermittent sunshine on the no-lift balloon is thus apparent. It would be of interest to know whether Mr. Mirrlees found significant differences between observations on occasions of sunshine and those on occasions of overcast sky ?

J. S. DINES.

Meteorological Office, October 4th, 1938.

NOTES AND QUERIES

Waterspouts off Bexhill

On the morning of September 1st, 1938, a number of waterspouts formed in the English Channel near Bexhill. The waterspouts attracted considerable interest in the daily press and accounts therein varied considerably.

Two reports were received at Croydon : one from Mr. Sargent, the Curator of Bexhill Museum, and this is quoted in full below : the other was from Mr. Duggan, who was piloting a machine bound from Paris to Croydon. The accounts are of interest because of the description of the formation of the waterspouts. It will be seen that Mr. Duggan's account indicates the existence of a considerable vortex between the cloud and sea before there was any visible connection between the two.

Two waterspouts were seen by Mr. Duggan near the English coast at approximately 1000 B.S.T. The first was a fully formed waterspout about three miles south of Bexhill. The cloud base was estimated at 1,200 feet. The waterspout was leaning about 30° from the vertical and he estimated the thickness to be 150 feet. The inclination to the vertical gradually increased and the column broke up. Whilst this one was breaking up he noticed a pronounced lashing up of the sea about 1 mile from the waterspout. It seemed as if a small area of the sea was being whipped by a strong local wind and the spray was being swept up to form a cone : almost vertically over this disturbance a pronounced bulge grew downwards from the cloud base. The bulge from the cloud and the cone of spray from the sea both extended in length until they met about halfway, forming a nearly vertical waterspout of diameter about 400 feet. When last seen this waterspout was seen to be gradually inclining away from the vertical.

The following account was received from Mr. Sargent :—

"Five waterspouts, appearing successively, were observed off Bexhill between 0945 and 1010 B.S.T. on Thursday, September 1st, 1938. They were associated with a typical nimbus cloud with a base estimated at 1,500 feet, travelling from west to east. The northern boundary of the cloud passed over the town and there was a brief shower. Wind was light, westerly, becoming calm after the passage of the cloud. Visibility was good. The writer saw the last three waterspouts from the sea-front: their distance appeared to be about two miles. In one, the sea disturbance at the point of contact appeared to be considerable. Each waterspout commenced as an elongated pointed projection appearing pale grey against the dark cloud base, gradually increasing in length, assuming a graceful double curve, and becoming much attenuated and indistinct at its base. A small patch of sea became agitated, there was much spray, and one could clearly see the point of contact some seconds before there was any obvious connection between cloud and water. In one case the disturbance of the sea appeared to form a ring of spray with an apparently clear centre. Some observers stated that they could distinguish a rotating motion of the stem of the waterspouts, but I could not detect this (even with binoculars) in those which came within my personal observation.

"At one time two or three elongated cone-shaped extensions depended from the cloud, as of waterspouts in the process of formation but they did not develop. There was no apparent disturbance of the sea beneath, and they rapidly diminished in size and disappeared."

The meteorological conditions during this display were of the kind usually associated with waterspouts. The winds were light: a rather weak anticyclone was centred over Belgium and the wind at 1,500 feet in the eastern end of the Channel was 170°, 10 mi/hr. The normal temperature of the sea for the season in this part of the Channel is 61° F. The temperature of the free air at 3,000 feet was 46° F. which gave an average lapse-rate approximating to the dry adiabatic. Humidity considerations would provide for the cumulus bases to be about 2,500 feet. The fact that the cloud base was estimated to be as low as 1,200 feet showed a considerable lowering of the base (due perhaps to cooling on evaporation of rain from the main cloud) which would result in a lapse-rate between surface and cloud base considerably in excess of that in the free atmosphere—which was approximating to the dry adiabatic.

C. J. M. Aarensen.

The following account has been received from Mr. A. E. Moon, of Clive Vale, Hastings :—

" At 8h. 55m. (G.M.T.) to-day, September 1st, 1938, an unusually well developed water-spout was observed to WSW, with a shorter funnel to the east of it. The spout reached down to the surface of the sea, where a distinct white patch (apparently raised above the general sea level) could be seen ; a similar patch was also present under the short funnel. At 9h. 5m. all that remained of the spout was a long flat-S-shaped shaft of a light greyish colour touching the sea but not the cloud ; the white patch on the sea was still present. Shortly afterwards the shaft vanished very suddenly. Just to the west of this another short funnel formed and this was in very active motion, fragments of it appearing to rise very rapidly into the base of the cloud. The first water-spout and its remains had a definite drift from east to west between cloud and sea, i.e., the base of the spout being somewhat in advance of the summit. The water-spouts were at a distance of about two miles and the cloud base (which was not unusually heavy, not more so than a large cumulus cloud) in their vicinity about 1,000 feet above sea level ; cloud overhead was about 2,500 feet above station level. Low cloud at 3,000 feet at 7h. was moving from 180° at 10 m.p.h. A little before 9h. there was a very slight rain shower."

Waterspout on Lagan Canal

The Linen Industry Research Association, who are responsible for the rainfall station at Lambeg (Glenmore House) Co. Antrim, report that a waterspout was observed by three members of the staff. It was seen on the Lagan Canal at 13h. 30m. on September 9th, 1938, and reached a height of about three feet.

A Fireball seen at Broken Hill, Northern Rhodesia

A curious fireball passed near Broken Hill on the evening of April 28th, being first noticed about 8 p.m. when fairly high in the sky but somewhat to the west. It was luminous, orange in colour, and roughly pear-shaped, with a round head " about the size of a football ", and a tapering tail from which sparks or streamers emerged as from a firework. The total length appeared to be about three times the diameter of the head.

The object moved slowly across the sky from south to north, and was lost to view after about half an hour. Soon afterwards there was a loud detonation which caused a perceptible earth tremor, and was generally mistaken for late blasting on the mine. During the greater part of its course, the object gave light enough to read by, the brilliance diminishing only as it passed away to the north.

Some native witnesses claim to have seen the fireball burst and scatter, while others distinguished three " bangs " in the explosion though they did not see it. Unfortunately no statement of the interval between the visible and audible explosions is obtainable.

A report from Victoria Falls states that the fireball was seen there too at about 8 p.m., and that it appeared in the sky behind the Hotel and moved slowly northwards till lost to view. If we allow half an hour between the zenithal appearances at the Falls and Broken Hill respectively, its velocity must have been some 600 mi./hr. the direction of travel being from SSW to NNE. As the final explosion was visible to some watchers but not to others, while nothing was seen of the object at Ndola, 100 miles to the north, the end point could not have been far beyond Broken Hill. This suggests a rapid deceleration in the last half hour, and the apparent slowness of movement even at the Falls seems to indicate a path curving down towards the earth's surface from a considerable height, possibly from outer space.

[In forwarding this account, Mr. J. Coventry adds :—

" Strangely enough, another report came to hand some time later of a similar occurrence near Ndola. A coloured man stated that when travelling from Nkana to Ndola on the 20th of June at 6.30 p.m., he saw ' a lump of fire about the size of a big drum ' descending through the sky about four miles away, scattering sparks as it fell. He was so terrified by the sight that he got off his motor cycle and took refuge in prayer.

It would be interesting to know whether these strange visitants can be associated with known meteoric showers, or other such phenomena."]

Observation of a Radio Sonde Balloon with the Unaided Eye

During the flight of a Radio Sonde balloon sent up from Kew Observatory on September 13th, Mr. H. D. Henley was able to keep the balloon in sight with the unaided eye for a period of 49 minutes. At the end of that time the balloon was at its greatest height, about 9½ miles, as was learned from the radio signals. The balloon came down rather faster than it went up and fell at Cliffe-at-Hoo, near Rochester and 35 miles from the Observatory, so Mr. Henley's observation must have extended to a distance of about 20 miles in a direct line. It is reckoned that the diameter of the balloon at its highest point was about 12 feet so that the angular diameter, as seen from Kew, was about 24″.

For comparison it may be mentioned that the angular diameter of Venus, when the planet is nearest to us, is about 65″. At that time the planet turns its unilluminated side to us. When the planet is at the greatest apparent distance from the sun we see half of the illuminated side ; the angular diameter is then about 23″. This is the most likely time for observations of Venus in the daytime. Whether the balloon or the planet would be the brighter object cannot be decided as there is no information as to the proportion of the light falling on it which is reflected by an inflated balloon.

The Exceptional Warmth of March, 1938

Many comments were made at the time on the unusually high mean temperature experienced in the British Isles in March of this year. It is now possible to place on record the exceptional nature of the warmth and its almost universal extent over the British Isles. In 1923, the Meteorological Office produced Section IV of the "Book of Normals", which included the range and variation of temperature at a number of selected stations throughout the country. In this section are given the highest and lowest mean monthly temperatures for each of the twelve months at the stations under consideration for periods ending in 1921 and going back, in the majority of cases, to 1871. This table has been completed for the month of March up to 1938 except in the case of a few stations for which data are not now available. The results show the remarkable fact that throughout the British Isles March, 1938, had the highest mean temperature on record for March at all the stations examined except at Lerwick, Dungeness and the Scilly Isles.

The attached table gives for 26 stations the highest mean temperature for March from the earliest year to 1937 and the value for 1938. The last column in the table gives the deviation of the value for 1938 from the previous record. It will be noticed that in some instances the value for 1938 exceeds the previous record by more than 3° F.; for example, 3·3° F. at Buxton, 3·9° F. at Armagh, 4·5° F. at Aberdeen and 5·3° F. at North Shields. At Oxford the record goes back to 1815 and the value in 1938, 49·9° F. is 2·6° F. higher than the previous record which occurred in 1822.

It is noteworthy that March, 1938, followed an unusually cold March in 1937. Using the same selection of stations we find that with a few exceptions March, 1937,was the coldest March since before 1920. It was not, however, the coldest March on record; at numerous stations the coldest March occurred in 1883 or 1892; in parts of Scotland it was registered in 1919 and locally in north Scotland in 1891. The difference between the monthly mean temperatures in March, 1937, and March, 1938, is striking; it amounted to 15·8° F. at Balmoral, 12·2° F. at Tynemouth, 12·1° F. at Aberdeen, 10·9° F. at Armagh and 9·4° F. at Kew Observatory. The average annual range of mean temperature at these stations is only 19·9° F., 18·8° F., 17·7° F., 18·3° F. and 22·5° F. respectively.

The abnormal warmth of March, 1938, was not limited to the British Isles; its extent is indicated in the *Meteorological Magazine* for April, 1938, p. 75. The exceptional character of the excessive warmth in Germany is given by W. Piersig (1) in an article entitled "Milder März—Kühler Sommer?" and in the "Deutscher Witterungsbericht für März, 1938". We read that it was the warmest March at Munich in 100 years and at Köslin, Hanover, Erfurt, Cassel, Frankfort-o/M and Cleve since 1851.

L. F. Lewis.

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(1) *W. Piersig. Leipzig, Z. angew. Met., June, 1938.*

Table 1. Highest Mean Temperature in March at Selected Stations

Station	Period	Highest Mean	Year	1938 Mean	Deviation of 1938 from previous record
		°F.		°F.	°F.
Lerwick... ...	1871–1937	44·5	1929	44·3	− 0·2
Deerness ...	1871–1937	43·5	1929	44·7	+ 1·2
Stornoway ...	1871–1937	44·7	1933	46·3	+ 1·6
Fort William ...	*1884–1937	45·0	1933	46·7	+ 1·7
Aberdeen ...	1881–1937	43·9	1882 1935	48·4	+ 4·5
Edinburgh (Leith and Blackford Hill).	1871–1937	46·4	1874	47·7	+ 1·3
Rothesay ...	1876–1937	44·4	1894	46·7	+ 2·3
Douglas... ...	1878–1937	44·8	1929	47·2	+ 2·4
Tynemouth ...	1871–1937	44·8	1921	50·1	+ 5·3
Yarmouth ...	1872–1937	45·9	1921	48·8	+ 2·9
Cambridge ...	1876–1937	46·6	1893	48·5	+ 1·9
Buxton	1875–1937	42·5	1920	45·8	+ 3·3
Oxford	1871–1937	46·7	1933	49·9	+ 3·2
Greenwich ...	1841–1937	47·5	1841	49·7	+ 2·2
Kew	1871–1937	46·7	1912	49·3	+ 2·6
Dungeness ...	1886–1937	46·5	1903	45·6	− 0·9
Southampton ...	1871–1937	47·5	1896	49·3	+ 1·8
Southport ...	1871–1937	45·5	1933	47·0	+ 1·5
Stonyhurst ...	1871–1937	45·0	1871	46·5	+ 1·5
Holyhead ...	1872–1937	46·9	1893 1933	48·1	+ 1·2
Falmouth ...	1871–1937	48·3	1933	49·2	+ 0·9
Dublin (Phoenix Park).	1881–1937	45·5	1893	48·5	+ 3·0
Armagh... ...	1871–1937	45·2	1893	49·1	+ 3·9
Valentia Obsy....	1871–1937	48·9	1893	49·3	+ 0·4
Scilly	1871–1937	49·3	1893	48·7	− 0·6
Jersey	1871–1937	50·0	1893	50·2	+ 0·2

* 1884–1923, 1932–1937.

L. F. Lewis.

New Climatological Stations

New climatological stations, approved by the Meteorological Office have recently been set up by Mr. J. Porter at Garvagh (Moneydig), Co. Londonderry, by Mr. N. H. Middlebrook at Boston (Freiston Road), Lincs., and by Mr. Martin A. F. Sutton at the Royal Seed Establishment, Reading.

REVIEW

Relations between interdiurnal pressure and temperature variations in the troposphere and stratosphere over North America. By B. Haurwitz and W. E. Turnbull, Ottawa, Canadian Meteorological Memoirs, Vol. I, No. 3, pp. 67–92 (1938).

This is the third number of a new series of memoirs which should be a valuable organ for the communication of the results of the scientific work of the Canadian Meteorological Office, as well as a direct encouragement to its staff to embark on research.

The paper is a study of observational material which as yet, at least in relation to the extent of the North American continent, is scanty by comparison with the upper air data available for the relatively small area across the central part of western Europe to which most European data relate. But the American observations—and chiefly the eastern ones—have a new interest, for there the arriving air masses are of mainly continental type, having mostly travelled a considerable distance across the great land area lying to west and north. The European observational area on the other hand, with a great body of ocean occupying the corresponding position, has almost precisely reversed air-mass experiences.

Denoting the pressure and temperature changes at any given level from one day to the next by ΔP, ΔT, the first results noted are that surface pressure is more influenced by the temperature variations in the lowest layer than is the case in Europe. In 67 per cent. of cases the surface value of ΔP is of opposite sign to that of ΔT in the lowest kilometre and in only 33 per cent. of cases is it of the same sign ; in Europe the percentages are 62 per cent. and 38 per cent. The absolute mean values of the temperature variations in the lower troposphere are also decidedly larger in North America than in Europe—some 70 per cent. greater in the lowest two kilometres, and becoming about equal at 8 km. It is to be noted particularly that this arises rather from the extent to which lower level variations in Europe are damped down by surface influence than from any amplification of lower level as compared with higher level variations in North America. In fact, the mean interdiurnal temperature variation in North America is practically the same (around 4° C.) from surface level up to about 14 km., after which it falls off, whilst in Europe the mean starts at only about 2° C. at surface levels and rises to around 4° C. in the levels from 8 to 12 km. (upper troposphere and lower stratosphere), afterwards falling off again as in North America.

The correlation between the pressure near the surface and the height of the tropopause (H) is found to be small, of the order of 0·30 or less, but the correlation between P_5 and H is $+ 0\cdot89 \pm 0\cdot02$ for the American ascents and $+ 0\cdot82 \pm 0\cdot04$ for the Canadian ascents, values similar to those found by W. H. Dines for P_9 and H, from European ascents. The correlation between the pressure at

1 km. and the mean temperature up to 9 km. is small, but the correlation between P_9 and the mean temperature up to 9 km. is very high.

The memoir is entirely statistical, but it is expected that sufficient aerological material will be available soon to permit the study of some weather situations of special interest to be undertaken with special reference to the developments in the stratosphere and the higher troposphere. Such a study would be useful not only in itself, but because the comparison with corresponding European studies would be an important contribution to more general problems.

A. H. R. Goldie.

BOOKS RECEIVED

Rothamsted Experimental Station, Lawes Agricultural Trust. Report for 1937 (Meteorology, pp. 87–89), St. Albans, 1938.

Hong Kong : Annual Report of the Director of the Royal Observatory for the year 1937, Hong Kong, 1938.

Borough of Dover. Meteorological Report for 1937, Dover, 1938.

OBITUARY

Willis Ray Gregg. We regret to announce the death on September 14th, 1938, of Dr. W. R. Gregg, Chief of the United States Weather Bureau since 1934.

Gustaf Melander. We regret to announce the death on August 25th, 1938, of Professor G. Melander, formerly Director of the Central Meteorological Institute of Finland.

ERRATA

March, 1938. Page 52. Mean temperature for February.
for
Kew temperature, mean, 40·1°F : diff. from average −1·2°F.
read
,, ,, ,, 41·6°F : ,, ,, ,, +0·5°F.

September, 1938. Page 224. Mean temperature for August.
for
Kew temperature, mean, 61·3°F : diff. from average − 1·4°F.
read
,, ,, ,, 63·7°F : ,, ,, ,, + 0·7°F.

September, 1938. Page 203, line 5, *for* 1908, *read* 1938.

The Weather of September, 1938

Mean pressure was above 1020 mb. over the Atlantic west of Spain and Morocco, reaching 1025 mb. west of the Azores, and falling rather rapidly to 1004 mb. over south Greenland, Iceland and Spitzbergen. In Europe pressure rose towards the ESE from 1012 mb. in north-west Scotland to 1019 mb. in 20° E.; no data were received from Russia or Siberia. Pressure was 5 mb. above normal in mid-Atlantic and in the eastern Baltic, and 4 mb. below normal at Spitzbergen. In North America the highest values, 1017 mb., occurred round the Great Lakes, decreasing to 1012 mb. in southern California; deviations from normal were slight. No data were received for Canada.

Mean temperature was above 90° F. in central Egypt and Arabia, about 70° F. in the Mediterranean, 60° F. in central Europe, 54–59° F. over the British Isles and 48–57° F. in Scandinavia. In the United States they ranged from 80° F. in the south to about 60° F. near the Great Lakes. Temperatures were generally above normal, by more than 5° F. in Finland, Denmark and the north-western U.S.A., but southern Europe was slightly below normal. Rainfall generally differed little from normal but was rather heavy on the western coasts of Europe from central Scandinavia southwards and locally in the middle west of America.

Over northern and eastern India pressure was below 1005 mb. and slightly below normal, increasing south-eastwards to more than 1020 mb. in south-eastern Australia where it was 4 mb. above normal; New Zealand was also 3 to 4 mb. above normal. Temperature was above 80° F. in India and the tropics, 70° F. in Australia about 25° S., and 60° F. in southern Australia and 50° F. in central New Zealand. Temperatures were above normal over most of India, Siam, western and southern Australia, and below normal over French Indo-China, central and north-eastern Australia. Rainfall was deficient over all Australia and most of India, but there were large local excesses at Allahabad (16 inches, 9 inches above normal), Vizagapatam and Port Blair.

The weather of the month over the British Isles was dull, with mean temperature above the average. Rainfall exceeded the average in Scotland but in England and Ireland the distribution was variable.

On the 1st pressure was very uniform and weather cool with showers and bright intervals and local thunderstorms. During the following days pressure was high off the south-west coasts, while depressions moved south-east from the neighbourhood of Iceland causing rather unsettled, cool weather. Rain fell on the evening of the 2nd in the northern half of the country and on the 3rd over a somewhat wider area including east England though the south of England and South Ireland escaped. The depression which moved south-east over the country from the 5th to 7th caused rain at times in most places. Records of bright sunshine were good on the 2nd, particularly in England and southern Scotland, where the majority of stations registered more than 10 hours. Locally in the north and west of Scotland good records were obtained on the 7th; Lerwick and Stornoway reported 11·9 hours and 11·5 hours respectively. Low screen minima were registered locally on the first three days; for example, 26° F. at Dalwhinnie and 31° F. at Rhayader and Eskdalemuir on the 2nd and 31° F. at South Farnborough on the 3rd.

Between the 8th and 12th an extension of a large anti-cyclone on the Atlantic moved slowly southeast over the British Isles; rainfall was mostly slight during this period, though it was heavier in the north of Scotland on the 10th. Temperature continued rather low over most of England until the 10th but rose somewhat in Scotland and Ireland; on the 8th maxima of 73° F. and 71° F. were registered at Armagh and Fort Augustus respectively. The 12th was warm generally and 80° F. was reached or slightly exceeded at a number of stations in east and south-east England. The 13th was also warm in England and Ireland.

A trough of low pressure associated with a depression over Scandinavia moved south-east over the British Isles on the 13th and 14th; rainfall was moderately heavy locally in the north on the 13th and some rain occurred in most districts on the 14th. Cool polar air in the rear of this disturbance caused a considerable fall of temperature. A further period of unsettled weather ensued; between the 16th and 19th a depression off north-west Ireland moved in slowly over the British Isles and on the 20th and 21st secondaries to a depression south-west of Iceland travelled north-east over the country. Considerable rain fell at times and local thunderstorms were reported from the 17th to 19th and on the 21st; among the heavier falls of rain were 1·59 in. at Eskdalemuir on the 16th, 1·89 in. at Borrowdale, Cumberland, on the 17th and 1·65 in. at Bath, 1·81 in. at Purton, Wilts., and 2·17 in. at Weston Park, Warwick, on the 18th. On the 22nd an intense depression approached the west of Ireland and on the 23rd it moved north and became much less deep; gales were reported in the west and north on the 22nd and 23rd and rain occurred in the west and north on the 22nd and more generally on the 23rd, but many places in south-east and east England had little or none. Temperatures were high on the 23rd and 24th and reached 80° F. locally in south-east and east England. Between the 24th and 26th shallow secondaries moved northward over the British Isles causing rain at times and local thunder; a fall of 1·50 in. occurred at Tottenham, 1·59 in. at Furneaux Pelham, Hertford, and 1·75 in. at Much Hadham, Hertford on the 24th. On the 27th and 28th a depression south of Ireland moved north-east and on the 29th and 30th a low pressure system covered the British Isles; the weather was unsettled, with occasional rain but with periods of bright sunshine. Heavy rain occurred locally in south-east England on the 27th; 1·72 in. was measured at Heathfield, Sussex and 1·86 in. at Warbleton, Sussex.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway ..	112	+2	Chester ..	99	−31
Aberdeen ..	115	−11	Ross-on-Wye	105	−31
Dublin	84	−46	Falmouth ..	147	−11
Birr Castle ..	100	−19	Gorleston ..	137	−21
Valentia ..	107	−20	Kew.. ..	125	−21

Kew temperature, mean, 58·9°F: diff. from average, +0·4°F.

Miscellaneous notes on weather abroad from various sources

Snow fell in the Alps and Pyrenees in the early part of September—the earliest fall for many years. Heavy rain and hail caused serious floods in France and north-west Spain on the 10th; crops were damaged and many people were killed and injured in accidents due to subsidence of railway tracks and skidding cars. A series of typhoons swept across Japan between the 1st and 5th. The torrential rains and violent winds caused widespread damage to houses, bridges and ships, and over 100 persons are reported killed and thousands injured or rendered homeless. The monsoon continued weak in India with the exception of the Peninsula, Bengal experiencing flooding more severe than normal. Heavy rains in Quebec caused landslides and floods on the 1st, and 12 people were drowned. Hurricanes were reported from the West Indies on the 20th, and from New York and across to Canada on the 21st. Rivers burst their banks and whole towns in the north-eastern states were devastated. Over 500 lives were lost and the damage to property is estimated at £40,000,000. South Carolina was struck by a typhoon which caused 2 deaths on the 29th. In Argentine high temperatures were experienced during the month, the shade maximum at Buenos Aires reaching 89·4° F. on the 28th. The highest temperature reported on this date was 109·4° F. at Catamarca.

The Nile flood continued to rise to an abnormal level and incessant heavy rain in the Sudan caused houses to collapse in Khartoum.

(*The Times*—various dates.)

Seaplane struck by lightning

Mr. J. Durward writes to say that the seaplane *Cassiopeia*, in which he was a passenger was struck by lightning on September 8th, between St. Nazaire and Marseilles. No damage occurred and the pilot reached Marseilles safely although his hat was burned off his head and his hair singed.

Daily Readings at Kew Observatory, September, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain	Sun	REMARKS
			Min.	Max.				
	mb.		F.	F.	%	in.	hrs.	
1	1018·1	SSE. 2	42	65	61	0·02	4·2	ir_0 17h.–21h.
2	20·0	WSW 2	45	63	47	—	10·2	mw early.
3	22·2	WNW 2	42	63	50	trace	8·6	w early, r_0 22h.
4	23·0	NW 3	50	62	53	trace	4·1	pr_0 6h.
5	23·4	NW 3	45	64	50	—	3·1	w early.
6	14·2	SSW 3	52	64	80	0·07	0·4	pr 10h., tlr 18h.
7	09·2	NNE 2	52	63	60	0·09	3·1	r_0–R 18h.–22h.
8	20·0	NNE 5	52	63	75	trace	3·3	d_0 12h.
9	22·9	N 4	53	62	68	—	3·3	
10	23·8	NNE 3	51	64	55	—	3·0	
11	24·0	WNW 2	44	68	69	—	1·2	fe till 8h.
12	22·9	W 2	60	76	61	—	7·8	w late.
13	21·9	SW 2	57	76	63	—	8·3	
14	14·3	W 3	56	72	63	0·02	4·2	r–r_0 17h.–19h.
15	22·7	NW 2	48	61	49	—	10·4	
16	22·2	S 3	41	65	49	—	5·7	w early.
17	13·6	SW 4	49	69	51	trace	5·1	r_0 21h.
18	10·9	SSW 4	60	68	77	0·15	3·2	r_0 10h., r–r_0 22h.–24h.
19	08·7	S 2	56	65	70	0·06	1·3	r_0–r 0h.–2h., pr_0 10h.
20	03·8	SSW 4	54	65	73	0·06	1·2	r–r_0 4h.–7h. & 22h.–
21	07·2	SSW 2	53	61	85	0·05	0·0	ir_0 10h.–17h. [23h
22	14·9	S 4	52	67	60	—	10·3	w early.
23	12·6	SSE 3	56	76	58	trace	6·9	w early, pr_0 17 h.
24	12·1	SSE 2	57	72	67	0·40	1·3	ir_0–r 17h.–24h.
25	12·9	S 2	60	69	86	0·03	2·5	ir_0 0h.–10h. [23h
26	13·6	S 2	50	65	77	0·04	0·0	F–f 0h.–9h., r_0 17h.
27	16·1	SE 2	55	63	74	0·83	0·8	r–r_0 0h.–7h., 16h.–22h.
28	12·9	SSW 3	53	63	85	0·01	0·7	pr_0 0h. & 13h.
29	12·1	SW 2	55	64	66	0·04	3·5	r_0 4h.–5h. & 8h.–10h.
30	1014·1	SSE 4	47	65	59	0·07	7·7	r–r_0 16h.–17h.
*	1016·3	—	51	66	65	1·94	4·2	*Means or Totals.

General Rainfall for September, 1938

England and Wales	94	per cent of the average 1881–1915.
Scotland	127	
Ireland	105	
	—	
British Isles ...	105	

Rainfall : September, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
Lond .	Camden Square..........	2·38	131	*War* .	Birminghm, Edgbaston	1·90	106
Sur .	Reigate, Wray Pk. Rd..	2·59	125	*Leics* .	Thornton Reservoir ...	2·50	138
Kent .	Tenterden, Ashenden...	2·57	120	,, .	Belvoir Castle..........	2·52	135
,, .	Folkestone, Boro. San.	1·91	...	*Rut* .	Ridlington	1·58	82
,, .	Margate, Cliftonville....	2·38	121	*Lincs* .	Boston, Skirbeck.........	2·43	138
,, .	Eden'bdg., Falconhurst	2·58	114	,, .	Cranwell Aerodrome...	2·24	126
Sus .	Compton, Compton Ho.	1·91	68	,, .	Skegness, Marine Gdns.	3·21	177
,, .	Patching Farm..........	2·37	99	,, .	Louth, Westgate.........	2·07	102
,, .	Eastbourne, Wil. Sq....	2·53	101	,, .	Brigg, Wrawby St.......	2·50	...
Hants.	Ventnor, Roy.Nat.Hos.	1·91	77	*Notts* .	Mansfield, Carr Bank...	2·29	124
,, .	Southampton,East Park	1·69	77	*Derby*.	Derby, The Arboretum	2·91	169
,, .	Ovington Rectory.......	1·05	46	,, .	Buxton, Terrace Slopes	3·32	103
,, .	Sherborne St. John......	·79	39	*Ches* .	Bidston Obsy.............	1·68	70
Herts .	Royston,Therfield Rec.	2·55	136	*Lancs*.	Manchester, Whit. Pk.	1·83	77
Bucks.	Slough, Upton............	1·68	95	,, .	Stonyhurst College......	2·05	54
Oxf .	Oxford, Radcliffe.........	2·14	125	,, .	Southport, Bedford Pk.	2·24	81
N'hant	Wellingboro, Swanspool	1·90	105	,, .	Ulverston, Poaka Beck	3·40	80
,, .	Oundle	1·73	...	,, .	Lancaster, Greg Obsy.	2·01	59
Beds .	Woburn, Exptl. Farm...	1·29	72	,, .	Blackpool	1·53	54
Cam .	Cambridge, Bot. Gdns.	3·34	207	*Yorks*.	Wath-upon-Dearne......	2·08	132
,, .	March.......................	2·14	119	,, .	Wakefield,Clarence Pk.	2·43	152
Essex.	Chelmsford,County Gdns	3·48	202	,, .	Oughtershaw Hall.......	2·83	...
,, .	Lexden Hill House......	1·57	...	,, .	Wetherby, Ribston H..	2·21	123
Suff .	Haughley House.........	2·52	...	,, .	Hull, Pearson Park......	2·16	126
,, .	Rendlesham Hall........	2·30	88	,, .	Holme-on-Spalding......	2·58	148
,, .	Lowestoft Sec. School...	2·60	133	,, .	Felixkirk, Mt. St. John.	2·41	132
,, .	Bury St. Ed., WestleyH.	2·08	105	,, .	York, Museum Gdns....	1·66	102
Norf. .	Wells, Holkham Hall...	1·82	96	,, .	Pickering, Houndgate...	1·83	96
Wilts .	Porton, W.D. Exp'l. Stn	1·41	81	,, .	Scarborough...............	1·36	76
,, .	Bishops Cannings........	2·80	128	,, .	Middlesbrough............	1·76	106
Dor .	Weymouth, Westham.	2·01	96	,, .	Baldersdale, Hury Res.	1·88	75
,, .	Beaminster, East St....	1·91	75	*Durh* .	Ushaw College............	1·98	99
,, .	Shaftesbury	1·80	74	*Nor* .	Newcastle, Leazes Pk...	2·48	125
Devon.	Plymouth, The Hoe....	1·85	73	,, .	Bellingham, Highgreen	1·74	73
,, .	Holne, Church Pk. Cott.	2·14	60	,, .	Lilburn Tower Gdns....	1·65	70
,, .	Teignmouth, Den Gdns.	1·26	64	*Cumb*.	Carlisle, Scaleby Hall...	2·57	95
,, .	Cullompton	1·58	70	,, .	Borrowdale, Seathwaite	7·50	80
,, .	Sidmouth, U.D.C........	1·33	...	,, .	Thirlmere, Dale Head H.	5·59	86
,, .	Barnstaple, N. Dev.Ath	1·23	46	,, .	Keswick, High Hill......	3·65	86
,, .	Dartm'r,Cranmere Pool	3·40	...	,, .	Ravenglass, The Grove	3·16	94
,, .	Okehampton, Uplands.	1·45	45	*West* .	Appleby, Castle Bank...	1·79	71
Corn .	Redruth, Trewirgie......	2·44	78	*Mon* .	Abergavenny, Larchf'd	2·58	110
,, .	Penzance, Morrab Gdns.	2·87	98	*Glam* .	Ystalyfera, Wern Ho....	2·71	62
,, .	St. Austell, Trevarna...	2·32	73	,, .	Treherbert, Tynywaun.	4·17	...
Soms .	Chewton Mendip.........	2·74	89	,, .	Cardiff, Penylan..........	1·67	55
,, .	Long Ashton............	2·28	95	*Carm* .	Carmarthen,M. & P. Sch.	2·64	73
,, .	Street, Millfield..........	1·93	87	*Card* .	Aberystwyth	2·92	...
Glos .	Blockley	2·25	...	*Rad* .	BirmW.W.Tyrmynydd	1·77	46
,, .	Cirencester, Gwynfa....	3·51	160	*Mont* .	Lake Vyrnwy	2·15	61
Here .	Ross-on-Wye..............	1·15	60	*Flint* .	Sealand Aerodrome......	·96	50
,, .	Kington, Lynhales.......	1·28	60	*Mer* .	Blaenau Festiniog	4·16	58
Salop.	Church Stretton.........	1·43	70	,, .	Dolgelley, Bontddu......	3·08	72
,, .	Shifnal, Hatton Grange	1·39	72	*Carn* .	Llandudno	1·77	83
,, .	Cheswardine Hall........	1·32	65	,, .	Snowdon, L. Llydaw 9..	10·80	...
Worc .	Malvern, Free Library...	1·56	81	*Ang* .	Holyhead, Salt Island...	1·94	72
,, .	Ombersley, Holt Lock.	1·51	85	,, .	Lligwy	2·42	...
War .	Alcester, Ragley Hall...	2·09	117	*I. Man*	Douglas, Boro' Cem....	3·32	102

Rainfall : September, 1938 : Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent. of Av.
Guern.	St.Peter P't.Grange Rd.	1.60	62	*R&C* .	Stornoway,C.GuardStn.	4·19	112
Wig .	Pt. William, Monreith.	4·72	162	*Suth* .	Lairg	3·83	135
,, .	New Luce School	4·48	125	,, .	Skerray Borgie	...	...
Kirk .	Dalry, Glendarroch	4·92	134	,, .	Melvich	2·59	93
Dumf.	Eskdalemuir Obs	4·69	127	,, .	Loch More, Achfary	7·48	130
Roxb .	Hawick, Wolfelee	2.59	101	*Caith* .	Wick	2·93	117
,, .	Kelso, Broomlands	2.08	109	*Ork* .	Deerness	2·29	79
Peeb .	Stobo Castle	3·01	119	*Shet* .	Lerwick Observatory	2·41	80
Berw .	Marchmont House	2·47	102	*Cork* .	Cork, University Coll.	2·71	101
E.Lot .	North Berwick Res.	3·24	155	,, .	Roches Point, C.G. Stn.	3·62	122
Midl .	Edinburgh, Blackfd. H.	2·15	105	,, .	Mallow, Longueville	2·66	111
Lan .	Auchtyfardle	3·21	...	*Kerry*.	Valentia Observatory	5·94	143
Ayr .	Kilmarnock, Kay Park	4·16	...	,, .	Gearhameen	6·30	103
,, .	Girvan, Pinmore	4·85	127	,, .	Bally McElligott Rec.	4·44	...
,, .	Glen Afton, Ayr San.	5·13	132	,, .	Darrynane Abbey	4·01	113
Renf .	Glasgow, Queen's Park	3·44	124	*Wat* .	Waterford, Gortmore	3·26	119
,, .	Greenock, Prospect H.	5·03	112	*Tip* .	Nenagh, Castle Lough.	1·96	70
Bute .	Rothesay, Ardencraig	5·55	137	,, .	Cashel, Ballinamona	3·09	128
,, .	Dougarie Lodge	4·92	129	*Lim* .	Foynes, Coolnanes	3·21	111
Arg .	Loch Sunart, G'dale	7 10	113	,, .	Limerick, Mulgrave St.	4·40	167
,, .	Ardgour House	8·50	...	*Clare* .	Inagh, Mount Callan	...	...
,, .	Glen Etive	11·83	153	*Wexf* .	Gorey, Courtown Ho.	2·51	102
,, .	Oban	5·70	...	*Wick* .	Rathnew, Clonmannon.	2·41	...
,, .	Poltalloch	5·17	113	*Carl* .	Bagnalstown,Fenagh H.	2·66	108
,, .	Inveraray Castle	9·52	148	,, .	Hacketstown Rectory	2·44	87
,, .	Islay, Eallabus	3·96	95	*Leix* .	Blandsfort House	3·10	114
,, .	Mull, Benmore	16·30	142	*Offaly*.	Birr Castle	2·04	89
,, .	Tiree	4·86	131	*Kild* .	Straffan House	2·04	91
Kinr .	Loch Leven Sluice	4·45	173	*Dublin*	Dublin, Phoenix Park.	1·37	72
Fife .	Leuchars Aerodrome	2·93	152	*Meath*.	Kells, Headfort	2·08	78
Perth .	Loch Dhu	7·65	134	*W.M* .	Moate, Coolatore	...	...
,, .	Crieff, Strathearn Hyd.	4·21	147	,, .	Mullingar, Belvedere	2·09	78
,, .	Blair Castle Gardens	3·76	159	*Long* .	Castle Forbes Gdns	2·54	88
Angus.	Kettins School	2·78	126	*Gal* .	Galway, Grammar Sch.	2·18	69
,, .	Pearsie House	4·58	...	,, .	Ballynahinch Castle	5·86	123
,, .	Montrose, Sunnyside	3·51	176	,, .	Ahascragh, Clonbrock.	2·45	79
Aber .	Balmoral Castle Gdns.	2·81	117	*Rosc* .	Strokestown, C'node	2·47	91
,, .	Logie Coldstone Sch.	4·26	183	*Mayo*.	Blacksod Point	3·96	102
,, .	Aberdeen Observatory.	3·60	162	,, .	Mallaranny	5·81	...
,, .	New Deer School House	2·22	88	,, .	Westport House	3·56	100
Moray	Gordon Castle	3·84	154	,, .	Delphi Lodge	9·44	125
,, .	Grantown-on-Spey	4·04	163	*Sligo* .	Markree Castle	3·27	98
Nairn.	Nairn	3·44	156	*Cavan*.	Crossdoney, Kevit Cas.	2·72	...
Inv's .	Ben Alder Lodge	4·90	...	*Ferm* .	Crom Castle	2·55	91
,, .	Kingussie, The Birches.	3·29	...	*Arm* .	Armagh Obsy	2·17	88
,, .	Loch Ness, Foyers	3·31	113	*Down*.	Fofanny Reservoir	5·82	...
,, .	Inverness, Culduthel R.	2·89	123	,, .	Seaforde	3·17	115
,, .	Loch Quoich, Loan	9·25	...	,, .	Donaghadee, C. G. Stn.	3·05	128
,, .	Glenquoich	9·66	112	*Antr* .	Belfast,Queen's Univ.	2·59	101
,, .	Arisaig House	6·63	110	,, .	Aldergrove Aerodrome.	2·75	111
,, .	Glenleven, Corrour	...	...	,, .	Ballymena, Harryville.	3·75	121
,, .	Fort William, Glasdrum	5·17	...	*Lon* .	Garvagh, Moneydig	3·05	...
,, .	Skye, Dunvegan	6·71	...	,, .	Londonderry, Creggan.	3·15	95
,, .	Barra, Skallary	4·23	...	*Tyr* .	Omagh, Edenfel	2·40	79
R&C.	Tain, Ardlarach	3·57	142	*Don* .	Malin Head	3·67	113
,, .	Ullapool	4·43	118	,, .	Dunfanaghy	...	...
,, .	Achnashellach	5·57	77	,, .	Dunkineely	2·59	...

Climatological Table for the British Empire, April, 1938

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
	Mean of Day M.S.L.	Diff. from Normal.	Absolute. Max.	Absolute. Min.	Mean Values. Max.	Mean Values. Min.	Mean Values. ½ Max. and Min.	Mean Values. Diff. from Normal.	Mean Wet Bulb.			Am'nt.	Diff. from Normal.	Days	Hours per day.	Per-centage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy	1026·2	+11·8	63	30	54·1	38·7	46·4	− 0·7	39·6	80	7·2	0·09	− 1·36	3	5·0	36
Gibraltar	1014·8	− 1·6	71	50	62·5	54·6	58·5	− 2·4	53·7	82	7·1	3·13	...	15	...	...
Malta	1013·8	+ 0·4	71	47	62·0	52·6	57·3	− 3·6	52·9	79	5·9	1·09	+ 0·23	10	7·8	60
St. Helena	1015·5	− 1·1	70	59	67·8	60·7	64·3	0·0	62·0	91	8·0	2·22	− 1·00	17	...	...
Freetown, Sierra Leone	1010·2	+ 1·1	92	74	88·2	76·0	82·1	...	75·3	73	4·7	0·77	− 3·29	4	...	...
Lagos, Nigeria	1009·5	+ 0·1	91	72	88·3	76·0	82·1	− 0·7	77·0	82	6·5	6·03	− 0·05	13	6·3	52
Kaduna, Nigeria	1008·5	...	100	63	95·0	72·0	83·5	+ 1·3	70·8	66	4·9	2·04	− 1·04	7	9·2	75
Zomba, Nyasaland	1010·8	− 1·7	83	58	79·0	64·6	71·8	+ 2·5	69·7	83	6·0	3·37	− 0·29	9	...	...
Salisbury, Rhodesia	1012·3	− 1·8	84	51	78·9	56·2	67·5	+ 1·8	61·1	70	3·4	1·33	...	5	9·0	77
Cape Town	1015·2	− 1·2	86	48	71·9	55·6	63·7	+ 0·5	57·3	88	5·0	3·13	+ 1·26	12	...	...
Johannesburg	1013·6	− 1·7	79	43	70·0	52·7	61·3	+ 1·3	53·3	64	4·2	5·27	+ 3·53	9	6·9	60
Mauritius	1014·1	+ 0·2	85	60	81·7	69·8	75·7	− 0·1	72·7	77	5·6	4·64	− 0·48	16	6·7	58
Calcutta, Alipore Obsy.	1006·0	− 0·3	107	75	99·0	79·7	89·3	+ 3·7	78·8	78	3·6	0·01	− 2·17	0*	...	...
Bombay	1008·1	− 0·7	93	74	90·7	78·3	84·5	+ 1·4	76·3	74	3·1	0·00	− 0·05	0*	...	...
Madras	1008·0	− 0·4	96	75	91·7	78·1	84·9	− 0·4	78·5	73	5·2	0·00	− 0·63	0*	...	...
Colombo, Ceylon	1009·0	+ 0·3	88	72	86·8	75·3	81·1	− 1·6	78·0	80	6·5	15·57	+ 5·84	27	6·7	55
Singapore	1009·2	+ 0·3	90	73	86·7	75·7	81·2	− 0·4	78·5	78	6·9	8·81	+ 1·18	20	5·4	45
Hongkong	1012·2	− 0·4	86	61	77·7	68·1	72·9	+ 2·1	67·7	71	4·7	1·85	− 3·80	5	6·8	54
Sandakan	1008·1	...	90	73	87·3	76·0	81·7	− 0·5	77·7	85	8·4	9·26	+ 4·77	17	...	...
Sydney, N.S.W.	1015·6	− 2·8	88	49	74·3	59·7	67·0	+ 2·3	60·8	67	4·6	2·39	− 3.13	11	6·2	55
Melbourne	1014·9	− 4·6	95	42	72·8	52·7	62·7	+ 3·2	55·3	69	5·7	1·05	− 1·12	7	5·7	51
Adelaide	1016·6	− 3·2	99	44	75·1	56·3	65·7	+ 1·8	57·3	56	5·6	5·81	+ 4·09	11	5·3	48
Perth, W. Australia	1017·2	− 1·2	94	45	74·8	56·7	65·7	− 1·1	58·2	64	5·8	1·85	+ 0·20	5	7·1	63
Coolgardie	1016·2	− 2·1	102	42	80·0	55·3	67·7	+ 2·7	60·3	76	3·9	0·12	− 0·84	2	...	...
Brisbane	1014·2	− 3·4	94	50	80·6	62·6	71·6	+ 1·3	64·2	69	4·2	1·01	− 2·76	8	7·7	67
Hobart, Tasmania	1013·5	− 1·3	80	40	64·1	49·0	56·5	+ 1·3	51·5	72	6·4	1·28	− 0·57	15	4·3	39
Wellington, N.Z.	1019·1	+ 1·0	81	46	65·4	54·4	59·9	+ 2·8	58·2	87	8·4	7·12	+ 3·24	20	2·9	26
Suva, Fiji	1011·4	+ 0·8	88	69	85·3	73·7	79·5	+ 0·9	75·3	83	3·8	4·96	− 7·25	18	5·6	48
Apia, Samoa	1009·8	− 0·1	88	73	85·5	74·6	80·1	+ 1·2	76·5	80	5·1	6·55	− 3·60	16	7·0	59
Kingston, Jamaica	1014·2	+ 0·1	88	66	85·4	68·8	77·1	− 1·3	68·0	78	2·7	0·37	− 0·87	4	5·8	46
Grenada, W.I.	1011·7	− 0·8	88	70	86	72	79	+ 0·1	73	74	6	7·84	+ 5·68	18	...	...
Toronto	1016·4	+ 0·3	83	20	54·2	38·2	46·2	+ 4·1	39·0	69	5·9	1·75	− 0·54	11	5·6	42
Winnipeg	1016·0	− 0·7	69	4	49·5	26·1	37·8	+ 0·1	26·5	73	4·2	1·10	− 0·30	8	6·8	50
St. John, N.B.	1016·3	+ 2·9	68	12	47·3	33·1	40·2	+ 1·2	35·3	82	8·0	4·15	+ 0·64	18	4·6	34
Victoria, B.C.	1017·6	+ 0·1	63	34	56·6	43·5	50·1	+ 2·2	48·3	86	6·2	1·91	+ 0·39	8	10·5	77

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

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LONG-RANGE FORECASTING

By C. E. P. Brooks, D.Sc.

The detailed forecasts for 24 hours or less, based on synoptic charts, are designed to meet the requirements of aviation and shipping, as well as the day-to-day needs of the general public. For some purposes, however, such as agriculture, the issue of forecasts in more general terms for a longer period would be of great value, and in recent years investigations have been carried on in various parts of the world with this object in view. The forecast aimed at would cover a period from a week to a month, and would be based on the *type* of pressure distribution anticipated and the principal changes which it is likely to undergo during the period covered. The general character of the weather could then be filled in from any required aspect, but not the detailed weather conditions on any specified date. This is the definition of a " long-range forecast ", intermediate in scope between the detailed synoptic " short-range forecast " and the generalised " seasonal forecast " which is mostly limited to the departure from normal of one element, rainfall or temperature, over a period of three months or more. Although under favourable conditions the daily forecast may be extended, in the " further outlook ", over a period of three or four days, the ordinary synoptic methods are not suitable for regular long-range forecasting, and it has been necessary to seek for other lines of attack.

We may leave out of account here the many weather prognostics such as the oak and the ash, or St. Swithin of dubious memory. More debatable—or at least more debated—are the famous Buchan cold and warm spells, but whatever we may think of " St. Buchan ", every table of climatological normals is in one sense a long-range forecast, for it assumes that what has happened in the past will happen again in the future. In a climate such as that of Britain, however, the " normal " is not always a very good guide even for the average weather of a whole month. The range of variation of the monthly means may be considerable, while the normal itself is not always the most probable value. These difficulties are especially important in those elements, such as rainfall, which have a lower limit but no definite upper limit, and also in cloud amount, where figures of 0 and 10 may occur more frequently in the individual observations than intermediate amounts.

The best way to express climatological data as a guide to probable weather is the frequency table or frequency diagram, which shows the percentage of the observations falling within definite limits. This gives at once the limits beyond which occurrences are so rare that they may be ignored for practical purposes. Another example of a frequency table is one giving the percentage of winds from different directions ; this can be made more useful by giving also the frequency of different forces from the various directions. Frequency tables may be useful guides in regions of settled weather, but they are of comparatively little value for forecasting in the highly variable climates of the temperate storm belts.

What we have to do then, is to take the climatological normals as a basis, and seek to foresee how the actual conditions over a month or a season will depart from this standard. This is the basis of a seasonal forecasting, or " foreshadowing " by correlation of which India is the outstanding example.

The method in use was developed by Sir Gilbert Walker, and is based on the hypothesis that the weather in one part of the earth depends on preceding conditions in the same or other parts of the earth. In its inception this method was founded on physical reasoning, for it was supposed that heavy snowfall in the Himalayas in winter would inhibit the southwest monsoon. In practice, however, it was soon found that this was only one of many factors involved, and these factors were themselves inter-related to such an extent that the problem of tracing out even the more important connexions by physical reasoning proved too complex. Sir Gilbert Walker accordingly developed an alternative method. He collected series of data for a considerable number of places in all parts of the world, mostly in the form of means for three-monthly seasons, and worked out correlation coefficients between each of these and all the others, for the same season and for three and six months before and after. This was a formidable task but the labour involved was minimised by specially devised methods of calculation. From these correlation coefficients he picked out those which satisfy mathematical criteria of probability, and the process of constructing a formula for seasonal forecasts for any specified region then became almost mechanical.

This method at first sight appears crude and unscientific, but further reflection suggests that it has a real physical basis. The main variations of weather in any part of the world are associated with variations at certain key stations termed " centres of action ". Sir Gilbert Walker's method is to locate these centres of action by an exhaustive preliminary survey and then to go straight to his final objective, cutting out the intervening chain of cause and effect, which is generally tangled and obscure. The method is however not really applicable to the storm belts of temperate regions, where the changes of weather type are so rapid that " seasonal " forecasts, generalising the weather over a period of three months, are of comparatively little use.

Another possibility to which a great deal of attention has been devoted is forecasting by means of periodicities or " weather cycles ". At first sight the simplest and surest of all methods, periodicities have proved in practice to be of little value. For example, Brunt found that when all the best developed periodicities in the departures of the mean monthly temperatures at Greenwich from normal were eliminated, the effect was merely to reduce the standard deviation from 2·8° to 2·6° F., an almost negligible amount. It is true that when Brunt used these periodicities to calculate the temperature for a few years ahead, his calculated curves showed a fair measure of agreement with the observed values, but this was probably a temporary accident. Nearly every attempt at forecasting by periodicities, especially in temperate latitudes, has speedily broken down. The reason is that weather cycles are not true periodicities in the mathematical sense, but are subject to variations of phase, amplitude and length. An apparently well-established cycle may die out completely and be replaced by another of different length, perhaps to reappear suddenly a few years later with a complete reversal of phase. Thus for about half a century the rainfall of England was dominated successively by cycles of five, three and two years, each of which in turn broke down completely. Until the laws, if any, which govern the succession of cycles have been made out, periodicities will remain untrustworthy guides to weather.

In tropical regions a certain amount of success has however been attained. About twenty years ago the Meteorological Office gave the Government of Gambia a successful qualitative forecast of the annual rainfall for the next few years, based on a combination of cycles. Recently a three-year cycle has been used in Java, but this is subject to changes of phase, apparently due to the interference of a cycle of seven years.

Owing to this general untrustworthiness, curves calculated from periodicities can be extended only for a short distance into the future, and the calculations need to be constantly revised. This method has been applied to curves of barometer readings, by Vercelli in Italy and on a more extensive scale by Weickmann in central Europe. The theory is that a curve dominated by periodicities will have nodes or "points of reflection", the curve after the node resembling that before the node, either simply reversed or reversed and inverted. If the nodes occur at the same time over a considerable area, there will be an ordered sequence of weather charts which can be used for detailed forecasts. Weickmann gives examples of such series extending over several months and in some cases a year, but it is very doubtful if the method could be used in practice owing to the difficulty of recognising in time the points of reflection, and the uncertainty as to how long the waves will persist. Further, it is to be noted that these waves are not well developed near sea coasts, so that the idea holds little promise for the British Isles.

Since deductive methods proved comparatively unsuccessful when applied to temperate latitudes, some attention has been given in this country and in Germany to empirical methods of long-range forecasting. The underlying assumption in these methods is that similar causes produce similar results, so that if at two different times the general atmospheric situation is clearly similar, the subsequent developments should also run parallel. This empirical method was in fact the basis of daily synoptic forecasting until comparatively recently, as is shown for example by the publication of Gold's "Aids to Forecasting" in 1920. For long-range purposes however it is necessary to distinguish between the persistent or structural features of the weather maps, including slow-moving anticyclones and centres of cyclonic activity, and temporary features such as rapidly moving secondary depressions. The temporary features can be smoothed out by making average maps over a period of time, from ten days to a month. Since this smoothing process also gives prominence to the permanent or "normal" seasonal features of the pressure map, the latter are eliminated by using differences from normal instead of the actual means of pressure. Hence the basis of the empirical method in this country has been the study of a series of monthly charts of deviation of pressure from normal over the northern hemisphere.

The direct application of the principle of causality proved disappointing, for even if the pressure charts for say January in two different years were closely similar, the charts for the following February might be widely divergent. The reason for this is probably that apparent similarity may cover considerable differences in the succession of changes within the month.

In Germany F. Baur got over this difficulty by using ten-day intervals instead of months and analysing a succession of charts for overlapping ten-day periods in great detail by a combination of synoptic and statistical methods. He also makes use of upper air data, on the hypothesis that the general weather changes must be governed by movements of air masses in the stratosphere, and he has in fact obtained considerable success by using the "steering" effect of the high-level pressure distribution to forecast the movements of areas of rising or falling pressure at the surface. A more detailed account of Baur's methods is given by Sir Gilbert Walker in the

Quarterly Journal of the Royal Meteorological Society for October 1937. They would be difficult to apply in western Europe because of the lack of regular upper air observations over the North Atlantic.

In this country the month was retained as the unit, mainly because monthly means of pressure for a large number of places were more readily available than means for shorter periods, and the changes from one month to the next were studied cartographically. A chart of pressure anomalies for a month generally shows one or more closed areas in which pressure reaches a maximum deviation above or below normal. These are analogous to the anticyclones and depressions of an ordinary daily weather map, and like the latter they generally occupy different positions on successive charts. Examination of a series of over 600 monthly charts showed that these centres of excess and deficit have a tendency to move from west to east, like ordinary anticyclones and depressions but much more slowly. In some parts of the northern hemisphere, for example from the Azores to the British Isles, there appears to be something approaching a definite track, but further north the movements are rather irregular. Unfortunately the life-history of a single " centre " is in general only from one to three or four months, and they sometimes appear or disappear abruptly. Their value for empirical forecasting is thus very limited.

Future progress along this line requires investigation in two directions, to discover if possible the physical significance of these centres of excess and deficit and their movements, and to relate these comparatively local changes of pressure to more widespread and slower seasonal changes in the atmospheric circulation.

Of the significance of the centres little can be said at present. In some cases they may be due to phenomena at a high level, possibly in the stratosphere. This is a feasible explanation of the centres of excess which tend to move northeastward from the Azores in spring, and which appear to be offshoots from the high-level warm Azores anticyclone. In higher latitudes however they may possibly represent the movements of large masses of cold or warm sea water. Both possibilities require examination in greater detail than has hitherto been attempted.

In the second direction rather more has been done, especially in connexion with variations in the amount and distribution of Arctic ice and subsequent pressure changes. For example, in January and February, 1938, the pressure distribution favoured steady winds from the south across the Arctic coasts of eastern Europe and western Asia. The result was to introduce much warm water into the Arctic and drive back the limits of ice. The rise of temperature and consequent fall of pressure in the Arctic gave a tendency for a northeastward shift of the whole pressure system of the North Atlantic, bringing the Azores anticyclone nearer to the British Isles and dominating the movements of the " centres " in the spring months. This was the immediate cause of the drought in the British Isles, and in this particular case it would have been possible to forecast the occurrence of drought from general considerations and to modify the forecast from time to time by reference to the monthly charts. This is only an isolated example however in which one factor dominated the situation and further investigation would be required to enable similar deductions from the general situation to be made regularly. Nevertheless this method probably presents the best prospect for successful long-range forecasting in the British Isles. It may also be practicable in south temperate regions, especially Australia and New Zealand, but the lack of data for the ocean to the westward would prove a handicap.

Note on some unusual observations of Cirriform Cloud

By S. T. A. Mirrlees

About 1530 (all times mentioned are G.M.T.) on Sunday, August 15th, 1937, at Newport-on-Tay, I observed what was apparently a fine display of hooked cirrus to southward. On fetching dark glasses and studying the clouds in the zenith I was surprised to see the cirriform cloud passing below a broken sheet of high stratocumulus which was moving from the opposite direction. With the aid of a hastily improvised nephoscope the following observations were made at 1600:—

Stratocumulus (estimated at 7,000 feet) moving from NNW at 15 radians/hr. " Cirrus " (at some level slightly below the stratocumulus) moving from SSE at 19 radians/hr.

The observations were made on clouds in the zenith or nearly so, the " cirrus " at the time being arranged in parallel bands lying E–W, and appearing as coarsely grained fibrous type.

The appearance suggested a wave motion but cirrus with more developed vertical structure was seen at 1630, moving fast from about SW and at 1900 similar masses were seen to SW still apparently moving fairly quickly from SW. None of the " cirrus " passing across the sun gave any halo phenomena. Towards dark the stratocumulus had become lower, but was still moving from a northerly point, and the cirriform cloud was not seen.

Mr. D. W. Cruickshank made the following observations :—" From a point about 2 miles NE of Leuchars on Sunday afternoon about 1500–1530 I observed hooked cirrus towards the south. As far as I could judge, the cirrus seemed to be moving towards the NW. Above it, moving in almost the opposite direction, there was what seemed to be altocumulus, some of it being lenticular, and at a height of about 10,000 feet. The cirrus was in parallel bands lying almost along the direction of motion. The clouds were almost between me and the sun so that it was difficult to see exactly, but they appeared to be moving at approximately the same speeds."

Mr. J. R. Sandison made the following observations:—" On Sunday, August 15th, 1937, at Tayport, about 5 miles north of Leuchars, I observed an unusual formation of cirrus cloud of *cirrus uncinus* type. The surface wind was W, force 3, and the lower cloud (5/10 fair weather Cumulus and Stratocumulus) was coming from approximately WNW. The cirrus which at about 1600 G.M.T. was moving from N–S and at a speed which I judged to be fairly rapid, first appeared in the NNW as fine white globular cloudlets arranged in thin parallel bands running E–W and from it long delicate filaments swept down and back towards N, appearing to pass below the stratocumulus, which was at a height of about 3,000 feet. Previous to this, at 1500 G.M.T., I had taken two photographs of the sky but unfortunately had exposed all my plates before the appearance of the cirrus."

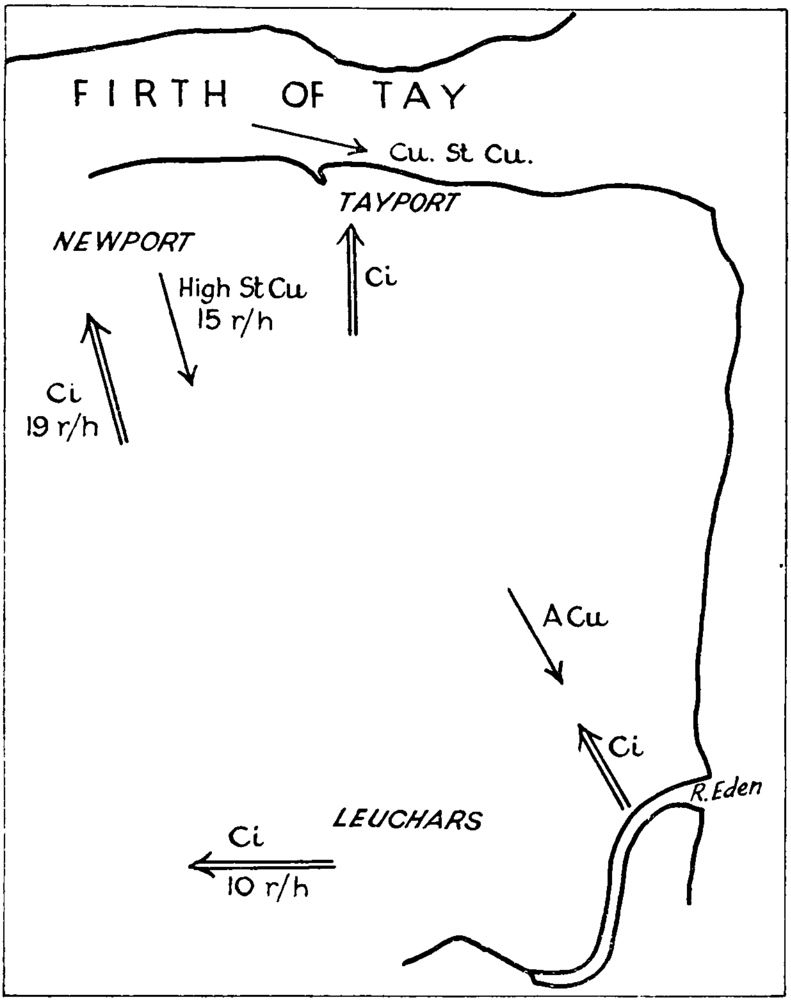

Fig. 1—Cloud Movements, Aug. 15th, 1937.

Mr. G. Froude, at the Meteorological Office, Leuchars, observed at 1600 cirrus moving from E at 10 radians/hr. The sky conditions were :—total cloud amount 6/10, low cloud (fair weather cumulus and stratocumulus) 3/10 estimated at 3,000 feet, medium cloud (single layer of altocumulus), high cloud (cirrus and cirrostratus increasing and reaching above 45° altitude). The surface wind was WNW, force 3, but at 1615 the direction changed to ESE.

The observations are shown in diagrammatic form on Fig 1. Although " cirrus clouds cannot at present be adequately discussed from the point of view of physical causes " (Meteorological Glossary, p. 43) and much remains to be discovered about the general question of cirriform cloud any observer may expect reports of cirrus cloud which come in the following two classes to be regarded with scepticism :—

(*a*) observations which imply the presence of cirrus at a level much below what is taken as " the cirrus level "—in such cases the reported velocity-height ratio in conjunction with an assumed height of 5 miles (8 kilometres) sometimes gives a very large figure for the velocity of the cirrus. To save repetition the term pseudo-cirrus may be used ;

(*b*) observations indicating in the same sky cirrus clouds travelling in directions differing by, say, 90° to 180°. The term anomalous cirrus movements may be used. A case of this kind observed at Leuchars is described in this Magazine for May, 1934, no explanation of the phenomenon being reached. It may be remarked in passing that the flow of air shown in some of the later developments of the Norwegian theory of upper-air structure seems to imply the possibility of such cirrus movements, although synoptic confirmation is probably lacking.

Occurrences of cirrus cloud at lower levels are by no means rare ; they have on occasion been confirmed by measurement of height with pilot balloons or range-finder. Where there is no such confirmation the question of optical illusion has to be considered, as in certain types of sky it is difficult to tell which of two layers is the higher. (The illusion is sometimes increased by making the observation from a quickly moving vehicle or railway train.) In the present case the type of the cloud above, together with the independence of the observations make it quite definite that the so-called cirrus was in reality below the " alto " level.

The *Daily Weather Report* and records from other stations in east Scotland have been examined, but no evidence is found for the existence of a large-scale discontinuity at lower levels, which, if it had existed, would presumably have been shown by disturbances on the barograms. The synoptic charts show a ridge of high pressure crossing the British Isles, while a slow-moving cold front which was off west Scotland on the evening of the 13th extended, on the afternoon of the 15th, from NNW to SSE about 200 miles off the east coast of Scotland. A pilot balloon ascent at Aberdeen showed north-westerly winds to above 8,000 feet ; at 18,000 feet the wind was 145°, 24 mi/hr, and at 18h. cirrus cloud was moving from 140° with an estimated speed of 45 mi/hr. A pilot balloon ascent at Leuchars at 1100 showed light north-westerly winds up to 3,000 feet.

Fig. 2 shows air trajectories deduced from anemograms (except for Leuchars, where there is no anemograph) for the period ending at 1700. The anemograms and barograms show only insignificant appearances of wave formations, although the appearance of the "cirrus" gave a suggestion of a wave or group motion.

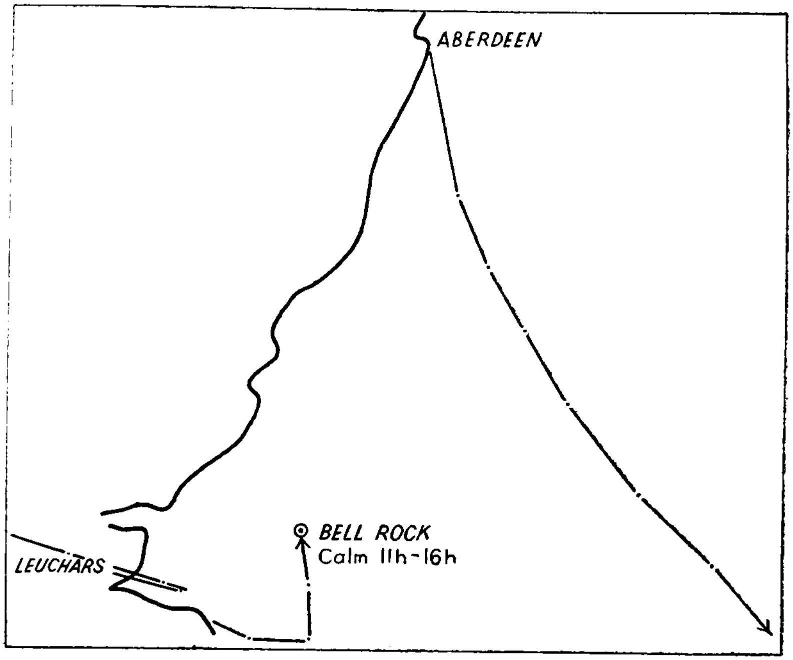

FIG. 2—AIR TRAJECTORIES (17H), AUG. 15TH, 1937.

The sea-breeze appeared at Leuchars at 1615 hours as a change in direction of wind from WNW to ESE inside, say, 30 minutes and probably after the time of observation of the low "cirrus". There is some rather vague evidence, though not on this occasion, pointing to the possibility of turbulent conditions at a surface separating "sea-breeze" air from warmer overlying air at some 2,000 feet above the Tay Estuary, conditions which in a suitable distribution of humidity might be indicated by cloud developments, and frontal invasions of sea-breezes have been studied at various places (e.g. Danzig). I have occasionally observed here, on days of vigorous convection with light winds, the early stages of formation of cumulus cloud at a fairly high level, give an appearance resembling two sets of cirriform clouds with a large relative motion.

However, while an explanation of the banded cirrus on the hypothesis of breaking waves on a sea-breeze front is tempting, it involves a certain amount of arguing in a circle, and is not justified by the aerological data available.

Questions for further investigation might be put in the following form; comments in brackets are based mainly on examination of a number of reports in the *Meteorological Magazine* from 1920 onwards:—

(1) Is the occurrence of "cirrus" at low levels confined to any particular region ? (Probably not, in British Isles.)

(2) Are occurrences of anomalous cirrus movements similarly localized ? (Little evidence, but probably not.)

(3) Is the occurrence of pseudo-cirrus associated with any particular synoptic situation ? (Region behind an occluded or cold front.)*

(4) Are occurrences of pseudo-cirrus and of anomalous cirrus movements expressions of different processes, or are they correlated to any extent ?

(5) What are the circumstances in which a cloud of water drops presents the appearance of a cloud of ice crystals (except for the fact that it gives no halo phenomena) the temperature of the environment being sometimes above 32° F. ?

(6) What are the circumstances in which cirrus extending through great vertical distances, extends to low levels ?

(7) What is the significance of the fact that the form *cirrus uncinus* is so frequently mentioned in observations of pseudo-cirrus, and what is the bearing on the usual explanation of the formation of this type ? (Are there two distinct uncinus-forming processes ?)

I have put the questions in this form in the hope of suggesting some points for debate ; a further point is that much might be learnt if the forecaster himself could spend more time in observing cirrus (and other clouds) with the aid of some less primitive apparatus than is at present available.

In the course of discussion of low-level cirrus, Mr. G. A. Clarke, of Aberdeen Observatory, has kindly put at my disposal two interesting photographs, which are reproduced by courtesy of Mr. Clarke, along with his notes on the formations.

Fig. 3 "is a case (in summer time—date uncertain) of a band of cirrus, whose threads are hanging downwards and only slightly inclined to the vertical except at the extreme foot. These threads seemed to originate in and proceed from a rather dense band of white cloud not unlike an "anvil" from some cumulonimbus, though no cumulonimbus was visible. The interest here lies in the fact that the threads extend some thousands of feet vertically. As the cloud passed overhead it appeared as a narrow band and eventually, due to perspective, resembled ordinary thread-cirrus. The dark band at foot of photo is the upper edge of a bank of dark stratocumulus at perhaps 2,500 or 3,000 feet."

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* Since this was written an observation in the region behind a warm front has come to hand. See note by Mr. Cruickshank on p. 267, also *Daily Weather Report*, International Section, for 18h. on March 11th, 1938. A warm front some 200 miles east of Leuchars is indicated.

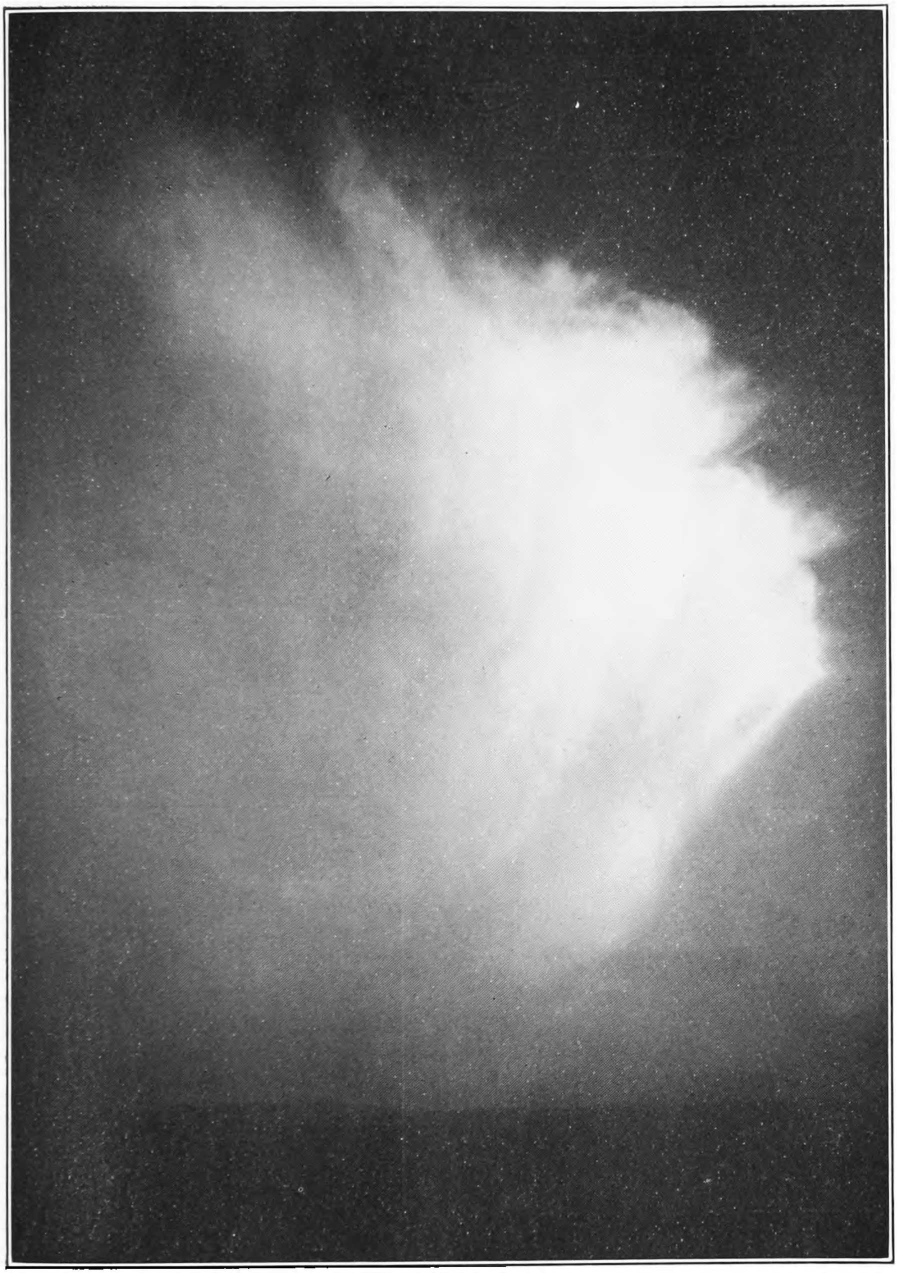

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FIG. 3.—CIRRIFORM CLOUD WITH NEARLY VERTICAL FILAMENTS.

Facing page 267]

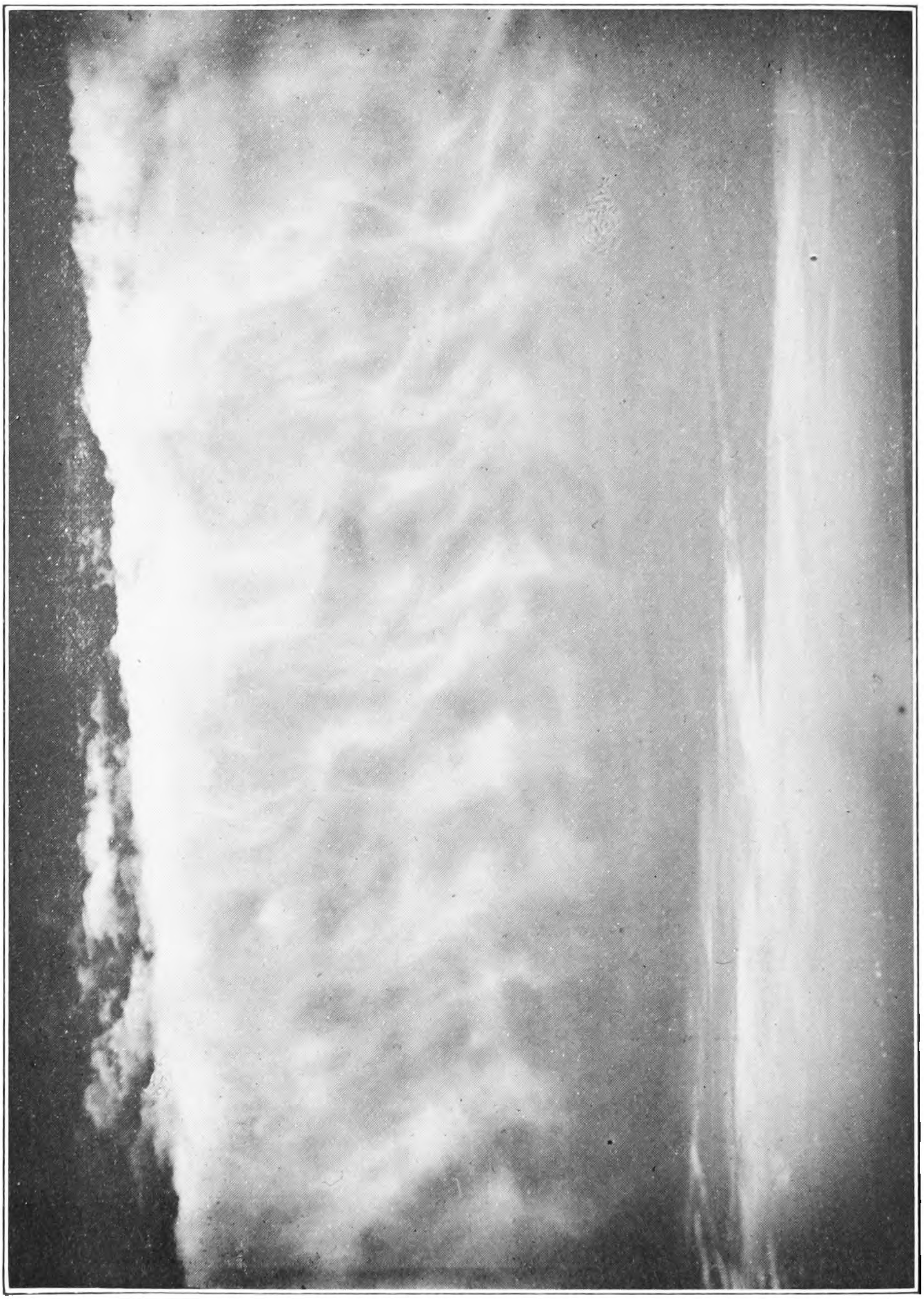


Fig. 4.—Cirriform Structure in Cloud of Altocumulus or Altostratus type.

Copyright: G. A. Clarke

There are some points here in common with Mr. Sandison's observations mentioned above; compare also the "cascade" of cirrus mentioned by Mr. D. L. Champion in *Meteorological Magazine*, June, 1936, p. 117.

Fig. 4 " is perhaps the most interesting of all. A sheet of altocumulus to altostratus (C_M7) was advancing from eastward (in which direction the observer is looking). From its leading edge brightly illuminated threads are descending. Perhaps these may be streams of snow. But the relatively dark sheet of altostratus against which they stand out, and beyond which the lighter sky is showing again, as it moved overhead broke up into altocumulus and rapidly dispersed, leaving the long wisps of apparent cirrus showing white against the blue sky."

An advance in the interpretation of observations of cirrus cloud, as in other problems of the upper air, appears to await the extension of aerological observations in general.

Observation of "Cirrus"-Form Cloud below Cumulus

By D. W. Cruickshank

At about 1800 on Friday, March 11th, 1938, from the village of Leuchars, I happened to notice a fairly large patch of cumulus and stratocumulus, with what appeared to be cirrus streamers underneath it. The prevailing type of low cloud at the time was large cumulus with stratocumulus and the height was about 3,000 feet. The patch to which my attention was drawn was due west and at an elevation of about 10°. Its position would have been approximately above the north-west slopes of Lucklaw Hill. In shape the mass was roughly lenticular with the ends "blunted" considerably, with the longer axis in an approximately SSW–NNE direction. The sun had set by this time though it was still shining on a few isolated patches of very high cirrus (hooked) and cirrocumulus to the west. The surface wind at the time was S.W, 5 mi/hr. and the wind at 3,000 feet (from a pilot balloon ascent) at 1630 was 45°, 2 mi/hr.

Besides the large cumulus and stratocumulus, there was also a certain amount of altocumulus in a single layer, and a considerable amount of hooked cirrus with a few small patches of cirrocumulus. My attention was first drawn to the low "cirrus"-form cloud by the colours on one of the cirrocumulus patches. This patch was above the southern end of the mass of cumulus and was just lighted by the setting sun. The centre of the cloud was pale pink in colour, this colour being uniform to the edge of the cloud. There a band of bright green took its place. The green colour was on the "south," "west" and "north" sides of the cirrocumulus. The two colours did not merge gradually into each other but the dividing line was quite sharply defined. The colouring lasted for about ten minutes till the sun's rays were off the cloud.

Underneath the patch of cumulus cloud I happened to notice what appeared to be cirrus streamers, in appearance exactly like the true hooked cirrus also present. The " low cirrus " passed underneath the smooth base of the cloud and turned up the near side, into which they seemed to merge. The direction of these streamers was not quite at right angles to the axis of the main cloud mass but roughly in a NW–SE direction. This fact was impressed on me because this was roughly the direction of the true hooked cirrus. (A nephoscope reading at the Meteorological Office, Leuchars, at 1800 gave 310° for the direction of motion of the cirrus.) The " low cirrus " lasted for about four minutes and then the underneath surface of the main cloud with which it was associated began to change quickly. Instead of being smooth it became much agitated, and corrugations running at right angles to the length of the cloud took the place of the " cirrus." The near edge of the cloud was also involved as it seemed to be " boiling " and turning over a horizontal axis. Owing to the failing light I could not see how long this lasted. At no time while I was observing the cumulus cloud did the sun shine on it as the sun was already below the horizon.

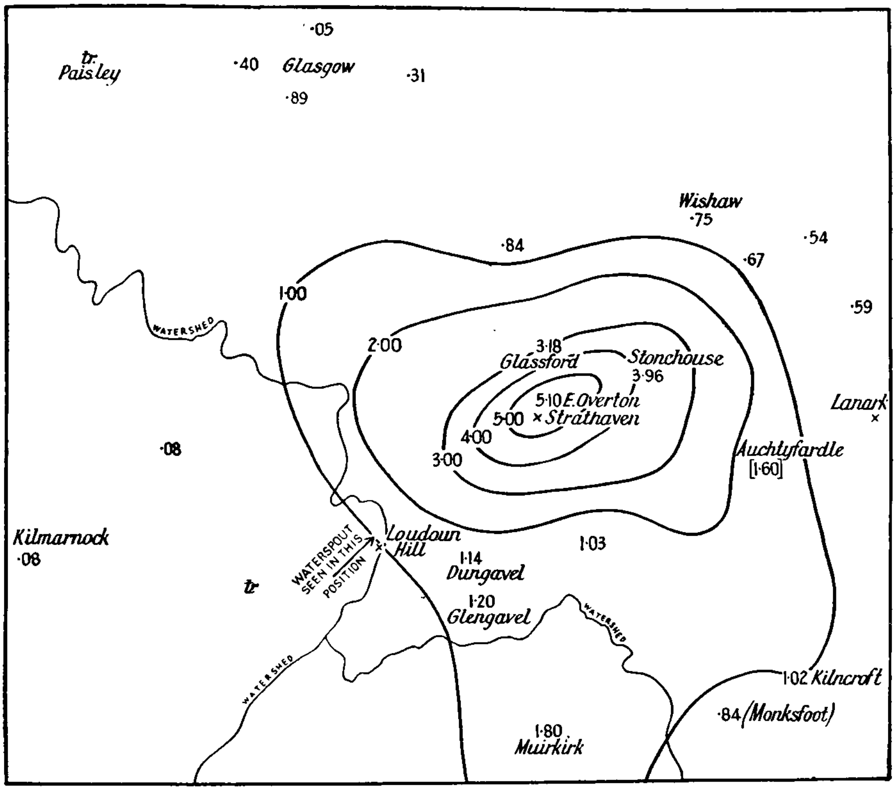
Waterspout and Intense Thunderstorm in Southwest Scotland on August 11th, 1938

By A. H. R. Goldie, D.Sc.

A waterspout was observed on the borders of Lanarkshire and Ayrshire on August 11th. In view of its apparently close connection with a patch of intense precipitation centred eight miles to northeast, in the direction towards which the upper end of the spout pointed, the complete circumstances of the case seem worth putting on record.

Mr. P. E. Kirton of Dungavel, near Strathaven in southwest Lanarkshire, described the waterspout in these terms : " At 4.10 p.m. what appeared to be a trunk-like structure of cloud shot out from near the edge of a nimbo-stratus cloud ; its length was enormous. The colour was white, it appeared to be suspended from the cloud and its direction was earthwards and running obliquely between the points northeast and southwest. From near the point of its origin the western sky was quite clear, with sunlight. Thunderstorms were approaching from the directions northwest and northeast and have proved to be of considerable intensity and duration. The phenomenon lasted nineteen minutes and no movement or alteration took place in its structure ; its disappearance was a matter of seconds and it appeared to be drawn straight back into the clouds. At the point of origin it was of considerable bulk and at its termination of vanishing point. This phenomenon was witnessed by a large number of estate workmen, many of them old men who declared that ' they had never witnessed such a thing before.' " In reply to an inquiry, Mr. Kirton said that the upper end which seemed to be directly above Loudoun Hill pointed towards northeast, and he supplied a sketch. The approximate position is indicated on the map, Figure 1. No movement was apparent during the whole of the nineteen minutes during which the phenomenon was under observation.

On the same afternoon flooding from heavy rain caused a landslide on the L.M.S. Railway between North and Central Stations, Strathaven. The landslide occurred between about 6.20 p.m., when a train passed safely, and 6.50 p.m., when the following train was derailed. A subsidence took place also on the railway line leading into Strathaven from Stonehouse. Flooding throughout the Strathaven district was extensive, roadways in various places were blocked and fields inundated. The thunderstorms of the same afternoon caused very considerable damage and flooding in many places in southwest Scotland, but the object of this note is primarily to describe what took place in the Strathaven district where the intensity was phenomenal. The places to which reference is made are shown on the map, Figure 1. All times quoted are Summer Time.


·05
tr.
Paisley
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WATERSHED
2·00
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Glassford
Stonehouse
3·96
5·10 E. Overton
5·00
× Strathaven
4·00
3·00
Lanark
×
·08
Auchlyfardle
[1·60]
Kilmarnock
·08
Loudoun Hill
WATERSPOUT SEEN IN THIS POSITION
1·14
Dungavel
1·03
tr
1·20
Glengavel
WATERSHED
WATERSHED
1·02 Kilncroft
·84 (Monksfoot)
1·80
Muirkirk

Scale: Approx. 8 miles to 1 inch

FIG. 1—DISTRIBUTION OF RAINFALL IN SOUTHWEST SCOTLAND, AUG. 11TH, 1938.

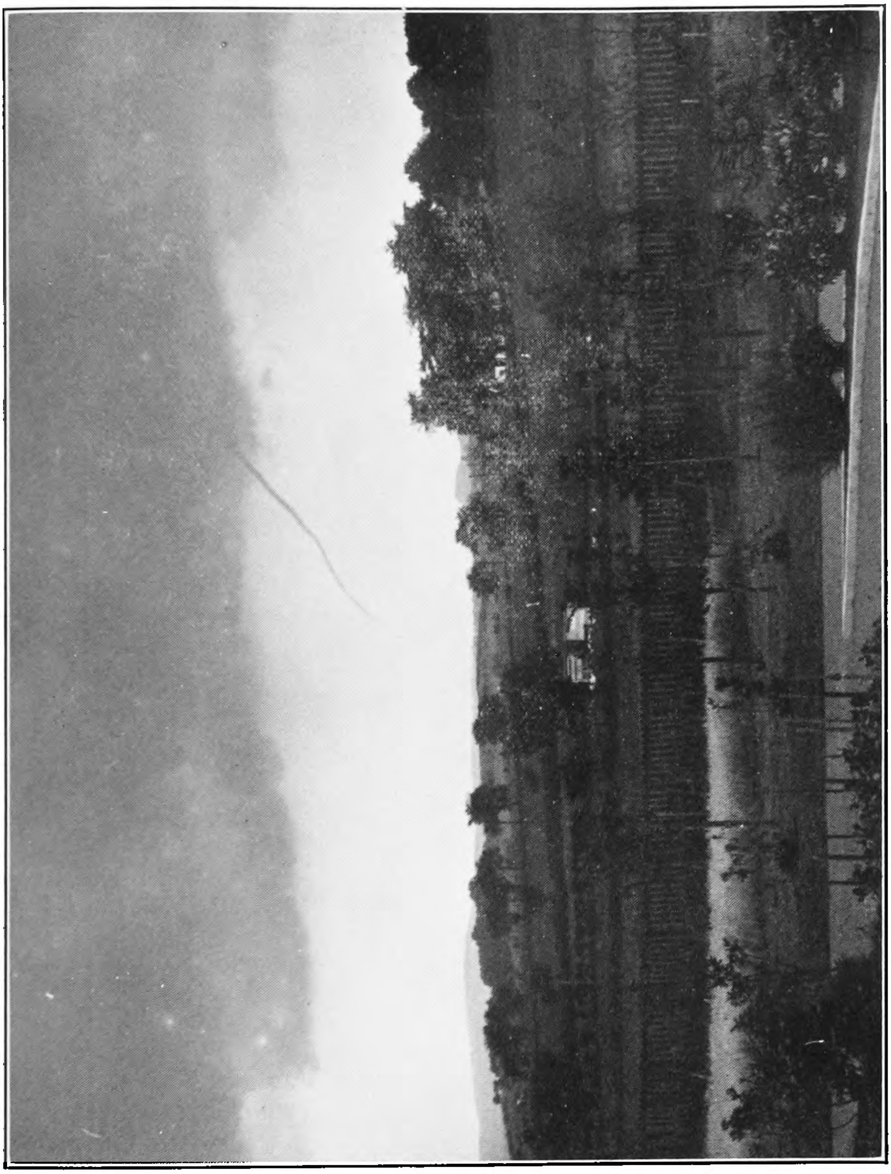
At East Overton House on the east side of Strathaven the precipitation from 3 p.m. to midnight was 5·10 inches. "Hailstones which came for about two hours were the size of pullets' eggs". The drive was washed down to the road, the garden ruined, and potatoes almost washed out of the ground. The gardener, Mr. W. Anton, says that at 3 p.m. there was a heavy shower at East Overton, but not in the town of Strathaven; at 3.45 p.m. heavy hail started and it continued for about 2½ hours. The tennis lawn which is surrounded by banks 10 to 14 inches high was filled to overflowing with hail and water. The thunder seemed to come first from east or southeast, then from south, then from west, and finally it was directly overhead. About the time when the hail was heaviest he saw ball lightning, "a ball of fire about the size of a football", pass over the house, under a great stone archway and away between some trees, with a tremendous crack, "a swishing noise" and leaving behind it a smell of burning.

At Stonehouse the fall for 24 hours ending 9 a.m. on the 12th was 3·96 inches, of which 3 inches fell between 4 p.m. and 9 p.m. on the 11th; the most intense precipitation was between 4 p.m. and 6 p.m. and included a heavy fall of ice hail, worst between 5 p.m. and 6 p.m.

The fall recorded at Glassford Filters was 3·18 inches and the rain there lasted from 4.20 p.m. to 10 p.m., being heaviest from 4.30 p.m. to 6.30 p.m. when about 2·5 inches fell. The Filter Keeper, Mr. John Lammie, and others at Glassford saw the waterspout for about a quarter of an hour and were able to confirm its position as being on the same bearing as Loudoun Hill. Its end was as described by Mr. Kirton of Dungavel. Mr. Lammie noted that the wind direction remained easterly throughout the storm. Thunder started in the southeast about 3 p.m., but the sun was still shining at Glassford Filters when the waterspout was first in evidence. The hail was heaviest from 5 p.m. to 6 p.m. Mr. Lammie gave it as his view that the maximum precipitation occurred somewhere in the gathering grounds of Muir Burn and Priest Burn, i.e. to the east side of East Overton House.

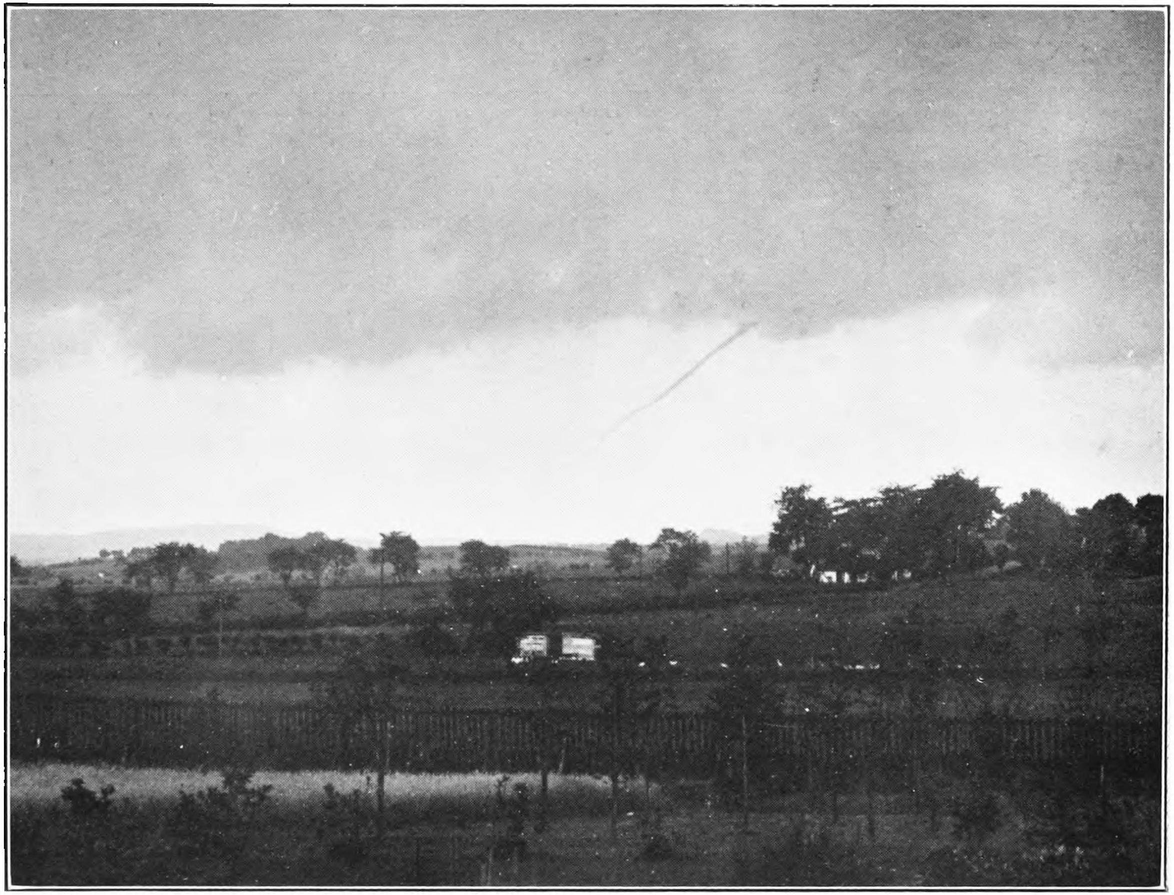
Mr. Hugh F. Dewar, Press Photographer, of Lamb Street, Hamilton, was also able to supply a description and the excellent photographs shown in Figures 2 and 3. He was talking to Sir Harry Lauder at a window in Lauder Hall (about a mile west of Strathaven) when the latter drew his attention to "a remarkable thing in the sky, coming down from a dark cloud." A thunderstorm was going on at the time. Mr. Dewar ran out to the front door with his camera and exposed two plates from that position looking up the Avon Valley towards Loudoun Hill in a southwesterly direction. The waterspout, he said, seemed to be hanging over the Strathaven–Darvel Road, which hereabout for a length of three miles points roughly towards Loudoun Hill. The photographs were taken about 4.15 p.m. at an interval of about two minutes on a Barnet Presto Plate, stop F8 at 1/50 sec.

At Glengavel the rain started at 5.10 p.m. and amounted to 1·20 inches. At Kype Reservoir the fall amounted to 1·03 inches,



Copyright : Hugh F. Dewar

FIG. 2.—WATERSPOUT, SOUTHWEST SCOTLAND, AUG. 11TH, 1938.



Copyright : Hugh F. Dewar

FIG. 3.—WATERSPOUT, SOUTHWEST SCOTLAND, AUG. 11TH, 1938 (ABOUT 2 MINUTES LATER THAN IN FIG. 2).

including very large hailstones for ten minutes. There was also ball and fork lightning. With the exception of an estimated value of 1·60 inches for Auchtyfardle (where rain is not measured every day), and 1·80 inches at Muirkirk, other falls in the surrounding area, though heavy, were mostly under an inch. The approximate distribution is shown by isohyets on the map. (Figure 1).

The synoptic chart for 13h. (2 p.m. Summer Time) on August 11th, as drawn at the meteorological station at Abbotsinch, shows a small shallow low over southwest Scotland and the Solway. It occupied the " col " between the major features of high pressures over the north Atlantic and Scandinavia, a low pressure over Iceland and wide shallow lows extending from England southeastwards over the continent. On the southwest Scottish coast winds were light northwesterly ; on the east coast and at Eskdalemuir and Abbotsinch they were easterly, also at Stonehouse and Glassford Filters. The boundary between northwesterly and easterly winds must, initially, have run approximately northwest to southeast through or to westward of Strathaven, and in fact the waterspout must have been lying in or very close to the surface of discontinuity. By about 7 p.m. the wind at Newmains, Douglas, had become northwest. No other record of the time of change in the Lanark area is available. At Edinburgh the change took place at 8 p.m. Summer Time. According to upper air observations at Aldergrove and Montrose the northwesterly current from the 900 mb. to the 700 mb. level was on the average some 4° F. warmer than the easterly one.

From 5,000 feet upwards, both currents showed rather steep lapse rates—somewhat steeper than the August normal—with considerable instability if surface temperatures should be raised—as they were by the day's insolation—to the order of 75° to 80° F. In these circumstances thunderstorms were to be expected. That phenomenal development took place in the Strathaven district must be attributed to coincidence with other favourable factors.

The Fourteenth Conference of the International Federation for Documentation

The International Federation for Documentation (formerly the International Institute of Bibliography) met at Oxford from September 21st to 25th, and was joined on the last two days by the Association of Special Libraries and Information Bureaux. Documentation is concerned with the rapid and concise supply of any information which may be required, and its importance to scientific and technical workers may be judged from the subjects discussed. These included : the making of abstracts from periodical literature, indexing systems, the practical use of bibliographies, photographic and " micro-film " methods of circulating information, systems of cataloguing and indexing, the organisation of information services, and library co-operation.

The Conference was especially concerned with the problem presented by the ever-growing volume of printed material, especially in the form of scientific and technical periodicals. It is almost impossible to keep track of all the literature of any one subject, while language difficulties make foreign works closed books to many readers. No one worker can possibly read even a tenth of that which refers to his own subject, even if he has the gift of tongues. During the discussions reference was made again and again to researches which had been repeated, sometimes at considerable cost of time and money, because the investigator did not know that they had already been carried out by some one else who had published his results. One investigation quoted had actually been repeated seven times. All this unnecessary work represents a great waste of effort which can be avoided by the proper use of bibliographies. One large research association has made it a rule not to authorise any proposed investigation until a bibliography of the subject has been compiled, in order to guard against such duplication. Bibliographies and, still more, abstracts are of very great value in supplying essential data and fruitful ideas and nearly every large technical organisation now has its own special information service.

The need for bibliographies and abstracts having arisen, it has been met to some extent, but in a haphazard and wasteful manner. In some subjects sufficient effort is put into abstracting to cover the literature twice, yet many important papers are missed. International co-operation is needed, such as that initiated so successfully in meteorology by the Bibliography Commission of the International Meteorological Organization, but applied to all knowledge instead of to separate sciences. Dr. Bradford has proposed that each country should have a central clearing house for abstracts, and if the present spate of publications continues unchecked, some such arrangement will soon become urgently necessary. In science as in economics we are threatened with a breakdown in the distribution of the products of labour.

The long-standing battle between the exponents of numerical and of alphabetical classifications was continued, but advantage inclines more and more to the former. Other problems usefully discussed included the transliteration of names from one language into another and the rules of alphabetical arrangement.

Great interest was aroused in a paper by Prof. A. F. C. Pollard on " The mobilization of knowledge and the ' Permanent World Encyclopaedia ' of Mr. H. G. Wells." The great objection to even the finest encyclopaedias, such as the *Britannica*, is that they are out of date almost as soon as they are published. The ideal solution would be a " loose-leaf " form to which new knowledge can be added as soon as it is published in research periodicals. This form of publication already exists in a few professions, notably medicine and law, and a more ambitious project is in hand in France. The movement will undoubtedly spread, and though the difficulties would be very great, modern methods of printing have brought it within the bounds of possibility, but the basis on which it must rest is scientific bibliography. Mr. Wells himself took part in the discussion and was warmly applauded.

Socially the Conference was highly successful and afforded an excellent opportunity for comparing ideas and methods in different countries, which is not the least valuable part of such meetings, and there was on view an exhibition of British abstracts, bibliographies and other publications in which the Universal Decimal Classification is employed. Meteorology was represented by *Geophysical Memoirs, Professional Notes* and the *Quarterly Journal, Memoirs* and *Bibliography* of the Royal Meteorological Society, making quite a good show.

On Monday, September 26th, the Conference re-assembled at the Science Museum, London, to witness an exhibition of microphotographic apparatus and to discuss problems of documentary cinematography.

OFFICIAL NOTICE

Discussions at the Meteorological Office

The series of meetings for the discussion of recent contributions to meteorological literature, especially in foreign and colonial journals, has been resumed at the Meteorological Office, South Kensington.

Meetings are held on alternate Mondays at 5 p.m. (tea is available from 4.30 p.m.) and the Director of the Meteorological Office wishes it to be known that visitors are welcomed at these meetings.

The discussions in October were as follows :—

October 17th, 1938. *The colloidal-meteorological processes in the formation of rain.* By W. Findeisen. *Met. Zs.*, **55**, 1938, pp. 121–133. (In German). *Opener*, Sir George Simpson.

October 31st, 1938. (1) *A method for the investigation of upper-air phenomena and its application to radio-meteorography.* By H. Diamond, W. S. Hinman and F. W. Dunmore, Washington, *J. Res. Nat. Bur. Stand.*, **20**, 1938, pp. 369–392. (2) *The determination of the meteorological conditions of the atmosphere by the use of radio-sounding balloons.* By H. A. Thomas. *London, Proc. R. Soc.*, **167** (A), 1938, pp. 227–250. *Opener*, Mr. G. J. W. Oddie.

The subjects for discussion at subsequent meetings are :—

November 14th, 1938. *Thermodynamic transformations in the stratosphere and iridescent clouds.* By J. Jaumotte. *Bruxelles, Mem. Inst. R. Met. Belge*, **5**, 1936, pp. 43. (In French). *Opener*, Mr. N. Bradbury.

November 28th, 1938. (1) *Fronts and boundary surfaces in theory and practice.* By P. Raethjen. *A. Hydr*, **66**, 1938, pp. 97–104. (In German). (2) *How weather is caused and how to foretell* *it.* By T. Bergeron. Ymer, Stockholm, 1937, pp. 199–229. (In Swedish). *Opener,* Mr. H. H. Lamb.

December 12th, 1938. (1) *Contributions to the dynamics of rainshowers.* By G. A. Suckstorff. Göttingen, *Nach. Phys. Astr. Geoph. Tech.*, **2**, 1936, pp. 9–49. (In German). (2) *On the temperature conditions and direction of travel of a rainshower.* By W. Schwerdtfeger. *Z.a.Met.*, **54**, 1937, pp. 76–85. (In German). *Opener,* Mr. G. R. R. Benwell.

The dates for the subsequent meetings are as follows:—January 16th and 30th, February 13th and 27th, and March 13th, 1939.

OFFICIAL PUBLICATION

Annual Report of the Director of the Meteorological Office presented by the Meteorological Committee to the Air Council for the year ended March 31*st,* 1938

The year under review has been one of progress towards providing the greatly increased meteorological services required to meet the ever-growing needs of the Royal Air Force and Civil Aviation. Steady recruitment of staff to both officer and assistant grades has continued and new meteorological stations on service and civil aerodromes have been opened as trained staff have become available.

A new system of communication with meteorological stations well distributed over the country was initiated during the year by the installation of direct teleprinter connexions between these stations and Headquarters, and work is proceeding on a large extension of this method of communication.

For the trans-Atlantic flights in July, 1937 the meteorological station at the Shannon Airport (operated on an agency basis by the Meteorological Office for the Government of Eire) and the meteorological station at Botwood (operated by the Meteorological Service of Canada on behalf of the Government of Newfoundland) supplied full meteorological information both prior to and during the flights. Subsequent to the flights conferences were held at Toronto and Dublin to review the meteorological organization and, so far as possible, to perfect the arrangements for the exchange and supply of meteorological information.

The Office is collaborating with the National Physical Laboratory in investigating a method of measuring upper air conditions by radio instruments carried on unmanned balloons. Two types of instrument are being developed, one for measurement of wind and the other for the determination of pressure and temperature, in the upper atmosphere.

On behalf of the Committee on Locust Control (Economic Advisory Council) the Office is conducting an investigation of the climatic conditions in Africa for the years 1925 to 1936, during which there were serious outbreaks of locust swarms.

Correspondence

To the Editor, *Meteorological Magazine*

August Frosts in Southern England

In connection with Mr. Donald L. Champion's report* of a grass minimum temperature of 29·3° F. at Goff's Oak, Herts, during the night of August 20th–21st, 1938, it may be of interest to record the occurrence on that occasion of the earliest " autumn " frost yet registered in the Stevenson screen at the Rickmansworth valley climatological station, to which Mr. Champion refers in his letter. By the standard thermometer the minimum reading there was 30·0° F. According to the trace of the thermograph, the temperature underpassed 40° F. at 22h. (G.M.T.) on August 20th, reached the freezing-point by 3h. 45m. on August 21st, and then sank slowly to 30·5° F. by 5h., a few minutes after sunrise. There was no apparent change until 6h. 15m., when the valley emerged from the shadow of the eastern hills and a rapid increase of warmth set in: 40° F. was attained by 7h. 45m., 50° F. by 8h. 50m., and 60° F. by 10h. 10m. The minimum at 1 inch above short grass was 23° F.

Hitherto, the earliest date for an " autumn " screen frost since observations were begun at the station 9½ years ago was August 26th, 1934 (31·9° F.). It is rare for *any* calendar month to pass without radiation frost (32·0° F. or lower) on at least one night in this Hertfordshire valley. From May, 1929 to September, 1938, there were only two such instances, the Augusts of 1930 and 1932, with extreme grass minima of 32·2° F. and 36·3° F. respectively. The period of the summer during which the standard thermometer 4 feet above the ground has not yet been below 32·0° F. at the Rickmansworth station now extends from July 1st to August 20th, 51 days. Having regard to the fact that 32·2° F. was recorded on July 31st, 1935, 34·6° F. on July 22nd, 1936, and 36·1° F. on August 10th, 1931, one can hardly doubt that over a long series of years in this particular corner of southern England there would be no gap at all between the last screen frost of " spring " and the first screen frost of " autumn," in whatever way the duration of these seasons may be defined.

E. L. HAWKE.

Ivinglea, Dagnall, Bucks, September 30th, 1938.

Snow in July at Sea Level

Mr. Robson's report† of genuine snow on the Lancashire and Cheshire coast on July 9th, 1938 is, of course, much more remarkable than it would have been on the original date given, June 9th. Occurrences of summer snow at sea-level in England should always be carefully described in the manner done by Mr. Robson, because most so called snow at that season is open to the suspicion of being fundamentally soft hail. The suspicion is not weakened from the stupid habit the newspapers have got into of announcing a foot or two of " snow " after every severe summer thunderstorm with drifting hail. The popular confusion between snow and hail would not matter so much if the meteorological associations of the two species of frozen precipitation were not so entirely different.

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* In the September issue of this Magazine.

† *See* pages 208 and 240.

Mr. Robson, unfortunately, has not stated the air temperature at the time the snow squall passed, which would have been of particular interest. We know that in mid-winter snow practically never falls with the temperature over 35° F., whereas in spring, from March onward, showers of snow frequently fall when it is over 40° F. The reason should be obvious: in winter, temperature over 40° F. signifies a warm current which can only carry rain, whereas in spring it may be due to shallow surface sun-heating in a bitterly cold polar current. During the night of July 10th–11th, 1888, snow is reported to have fallen around London, though the air temperature at Brixton reported in the *Daily Weather Report* did not drop below 44° F. The wintry squalls that crossed England on that date appear to have brought precipitation which varied from place to place between real snow, granular snow and soft hail; but records are scanty and it is not easy at this distance of time to find out in detail what really did happen.

L. C. W. BONACINA.

13, Christchurch Hill, Hampstead, N.W.3, October 21st, 1938.

The Great Gale of June 1st, 1938

When I was in charge of the South Farnborough Meteorological Office during the war there was a very severe gale from the south. There was a deposit on the windows of the Office which faced south and this deposit tasted distinctly salt.

The discolouration of foliage due to the gale of June 1st extended as far as here, 17 miles from the open sea, and even further for I saw traces of it as far inland as Newbury and Odiham, about 48 and 32 miles from the open sea respectively.

Summer gales from seaward do not ordinarily turn foliage brown, and it would be interesting to know why they should do so on rather rare occasions. Can it be that for this to happen there must be a period when the gale is strong but there is no rain, so that salt is blown inland and deposited on trees and not washed off again? Possibly there may be records from hyetographs and anemographs which would throw some light on the question.

C. J. P. CAVE.

Stoner Hill, Petersfield, October 30, 1938

Experiments with No-lift Balloons

The effect mentioned by Mr. Dines (in the October issue of this Magazine) must tend to introduce a systematic error, which could be measured only by statistical investigation of a much larger number of occasions.

The actual amount of superheating which might be present on a particular occasion is difficult to estimate. In bright sunshine the no-lift balloon ought to show a good example of greenhouse effect in so far as the isolating of a small mass of gas from the general convection is concerned. In the absence of any available literature dealing with the subject, assume that about 10° superheating occurred on the brighter days, giving a rise of about 100 feet/min. according to the figures calculated by Mr. Dines. If the rising velocities introduced had been appreciably greater it seems likely that some effect would have been noted in the working-up of the results, particularly in the comparison of the results as associated with stratiform and cumuliform clouds, but no definite conclusion was reached in this respect. Considering all the days on which experiments were made, the amounts of bright sunshine recorded were on the average little different from the seasonal averages, and it appears that the days can be regarded as a fair sample ; the inference is that the errors introduced by superheating were not in general larger than the other possible experimental errors.

While there is some support for this view in the consideration that the order of magnitude of the vertical currents measured at Leuchars was comparable with that found in experiments made by different methods in more or less similar exposures, the fact remains that the assumption that the " no-lift " condition is maintained on occasions of strong insolation may involve considerable errors.

S. T. A. MIRRLEES.

Meteorological Office, Leuchars, Fife, October 17th, 1938.

Blackening of Foliage by Gales

I have read your note on page 241 of the *Meteorological Magazine*, referring to the effect of the June gale.

I am 10 or 12 miles inland and experienced similar effects earlier this year (I think—though I cannot trace it in my diary). The leaves were all blackened and torn, and such things as rose petals suffered badly.

On the morning of October 4th this year, however, we had a gale ten times worse in its effects. Its severity may be judged by the number of trees down in the neighbourhood (500, I believe, in Knowsley Park) ; but the main effect was the blackening and shrivelling and tearing of all the leaves on the western sides of the trees and bushes. The tearing took place at the time, but the blackening only became evident a few hours later. Such flowers as dahlias were completely destroyed on the western side of the plant, but the more easterly half has since recovered. In places where there was some slight protection to act as a wind brake, there was slightly less blackening noticeable.

Within a few days all the affected leaves on the trees (*i.e.*, all except those well up on the east branches) had shrivelled up and fallen off in light breezes although they had not begun to change colour at the time of the gale.

Yesterday I was out picking blackberries. The bushes were entirely denuded of leaves and berries (though the skeletons of the leaves were often still on the bushes !) on the west side of the hedges, but on the other side the berries were many and good, and the leaves green, even on the same plant. It was raining practically continuously throughout the storm and again very soon afterwards.

In any westerly gale salt is deposited on my windows, 12 or 15 miles from the sea. My own opinion certainly was that the damage was caused by the destructive force of the wind on the wet and sodden leaves and plants, and not by the action of the salt, but on the other hand in travelling about I couldn't help observing that the effects on plant life were steadily less severe the further one got from this part of the country where the wind had come straight off the sea.

The minimum temperature, somewhere near the height of the gale was 47°, thus belying a popular impression here that frost was partly responsible for the unusual damage.

I hope this gives you some of the information you require.

W. H. PILKINGTON.

Windle Hall, St. Helens, Lancashire, October 24th, 1938.

[*Many letters are unavoidably held over owing to exceptional pressure on our space.*—EDITOR.]

NOTES AND QUERIES

The Hurricane of September 21st, 1938 in New England

Mr. Caleb Mills Saville, Chief Engineer of the Water Bureau of the Metropolitan District of Hartford County, Connecticut, has forwarded details of the severe storm which occurred in the east of U.S.A. on September 21st. A reference to the damage caused by this storm was given on p. 252. The Connecticut River rose to the second highest level ever recorded, being about 2 feet lower than that of March, 1936. The damage by flooding in 1938 was fortunately less than that of 1936, and this must be attributed in part to the precautions taken since 1936. The flood of 1938 was due mainly to widespread and persistent rains, more especially over the lower portions of the drainage area, whereas that of 1936 was caused by heavy rain on the upper regions augmented by the melting of snow and ice, which had occurred previously. The rainfall amounts recorded at West Hartford Reservoir for the five days September 18th to 22nd, 1938, were ·52, 2·10, 1·55, 4·92 and 1·07 inches respectively, a total of 10·16 inches. The maximum rainfall in one hour was 1·07 inches ; in six hours 2·57 inches ; in 24 hours 5·11 inches ; in 48 hours 7·18 inches, and in 72 hours 9·04 inches.

The heavy rain was associated with the passage of a low pressure system in a northerly direction. It was centred well to the east of Florida on the morning of the 20th, off the coast of North Carolina at 9h. on the 21st and near Ottawa at 9h. on the 22nd. The barogram at Hartford showed a remarkable fall on the 21st, *viz.*, 29·41 inches (996 mb.) at 11h., 29·25 inches at 13h., 28·92 inches at 14h., 28·28 inches at 15h. and 28·00 inches (948 mb.) at 15h. 30m. At 19h. the pressure had risen to 29·05 inches. It is reported that at the centre of the storm the barometric reading was 26·00 inches (880 mb.).

In some cases the wind velocity was estimated to exceed 100 mi/hr. and great damage was caused to property in Hartford by fallen trees. Remarkable damage also occurred along the shore, " both on account of the wind and its effect on the sea, which was similar to a tidal wave." Whole areas of beach development were wiped out, in one place as many as 400 cottages being destroyed. New coast-lines were also formed, in some cases the former character of the beaches being entirely obliterated. J. G.

Auroral Notes

The total number of aurorae seen in Scotland between August 1937 and May 1938, was 108, the highest total since 1929–30, and the figures for the first three months of the current season are also above the average.

August.—Aurora was observed from various places, chiefly in Scotland, on nine nights during August, an exceptionally high figure for that month. One display was visible as far south as Holyhead where, late on the 3rd, one white ray, which moved eastwards before disappearing, reached an elevation of 53° at 23h. 50m. Another display occurred on the following evening and was best seen by Mr. H. H. Lamb from Montrose where it appeared in the southern sky shortly after 23h. The most striking feature was the regular variation of intensity, with period two or three minutes, and the changes of colouring, gold, crimson, blue and vivid green being observed.

September.—No aurora was seen in September until the 13th, but during the remainder of the month it was reported on 13 nights and was seen from Lerwick on all but one of the nights when cloud permitted observation. The display of the 14th was visible over a wide area, and detailed accounts have been received from Mr. J. R. Sandison of Leuchars and Mr. H. E. Heaton of Abbotsinch, Mr. R. Forbes-Bentley of Holyhead and Mr. Lamb. The latter part of the display was also seen by the writer, who secured a photograph which does not, however, show more than a diffuse glow.

At 20h. 15m. a long homogeneous quiet arc was present and ray activity soon commenced in the west, most of the rays moving slowly eastwards before fading, although some moved in the opposite direction. Similar phenomena continued at intervals throughout the evening but the rays never appeared to extend any considerable distance from the arc.

Some rays in the northwest, as seen from Edinburgh at 22h. 15m., shot up from the horizon towards the arc and apparently originated in a second arc which slowly rose above the horizon and eventually merged into that already present. This second arc was narrow, having a uniform width of 3° and was also remarkable for two bright patches at azimuth 327° and 354° as seen from Leuchars. Further rays, moving eastward, appeared after the arcs had united but the aurora became quiescent and faded after 23h., although it was still visible from Abbotsinch at 23h. 30m. and from more northern stations until 2h.

The colouration was mainly greenish white throughout but some of the rays had a golden hue in their lower portions.

It has not been found possible to compute from the observations the exact height or position of the auroral arc, but it was probably at about 100 km. from the earth's surface and extended from Norway across Shetland to mid-Atlantic.

As is usually the case during active aurorae a severe magnetic storm was recorded. It began at 15h. 30m. on the 14th and continued throughout the night and following day. Between 16h. on the 14th and 3h. on the 15th the range of variation of the three components of the earth's magnetic field at Lerwick were :

Horizontal component	$1,526\gamma$	(·015 C.G.S. units)
Vertical ,,	843γ	(·008 C.G.S. ,,)
Declination... ...	2° 0′ ·8	

There was also interference with short wave wireless reception at Abbotsinch, especially on the afternoon of the 14th and 15th.

The displays of the 26th and 30th were also active and extended into the southern sky at Lerwick ; cloud prevented their observation from more southerly stations. On the 30th every type of aurora was seen, from quiet arcs to coronae ; the red patches which were so prominent in the display of January 25th to 26th also occurred.

October.—October is the month in which aurora occurs most frequently in these latitudes and this year it was seen on 15 nights, one more than the average number. As in September there were comparatively few displays in the first half of the month. The brightest and most active displays were those of the 7th and 26th ; on the 7th draperies and coronal types predominated and persistent flaming aurora was the chief feature on the 26th.

F. E. DIXON.

Dr. WILLIS RAY GREGG

Dr. Willis Gregg, Chief of the United States Weather Bureau, died on September 14th, 1938. He was born in Phoenix, N.Y., on January 4th, 1880. Dr. Gregg entered the U.S. Weather Bureau as an assistant observer in 1904, a year after having taken his B.A. degree at Cornell University. For several years he was stationed at the Mt. Weather Observatory where frequent upper air soundings were conducted, and it was there that his interest in aerology became deep-seated. When the Government later established a network of sounding stations, he soon took charge of the work and was the first to make a thorough study of the upper air conditions over a large section of the United States. As head of the division of aerology, to which he was appointed in 1917, his unique knowledge of the upper atmosphere together with the rapid development of aviation placed him in a position of singular responsibility and authority. In 1919 he served as a special meteorological adviser for the trans-Atlantic flight of NC planes (USN) at Trepassey, Newfoundland, and, in July of the same year, he served in the same capacity for the British dirigible R.34, at Mineola, N.Y. He was appointed, in 1922, to the National Advisory Committee for Aeronautics, meteorological sub-committee. Under his direction, the aerological division of the Weather Bureau expanded to such an extent as to become the largest in the service. He relinquished this post to become Chief of the Weather Bureau in 1934.

As head of this complex and important organization, he put in effect the recommendations of the Science Advisory Board, in the formulation of which his advice was frequently sought. The number of airplane sounding stations was increased from 6 to 20–25. Frequent maps were inaugurated for the entire country and for all types of activities and the method of air-mass analysis was introduced as a valuable supplement to the existing method of daily weather forecasting. In the development of a weather service for aeronautics, he attained a high and widely appreciated measure of success.

It was characteristic of Dr. Gregg that he obtained the co-operation of many independent organizations in the prosecution of meteorological research in his own country and abroad. As an active officer of the International Meteorological Organization, he was instrumental in bringing about greater co-operation between the United States Weather Bureau and meteorological services in other parts of the world.

Dr. Gregg was the author of a very valuable work on aeronautical meteorology and the co-author of two books on meteorology, besides contributing to various periodicals at home and abroad. He was a member of many distinguished scientific bodies, often serving in a high capacity. Norwich University conferred upon him, in 1937, the honorary degree of Doctor of Science.

I. I. Schell.

(Late U.S. Dept. of Agriculture.)

New Climatological Stations in Scotland

New climatological stations, approved by the Meteorological Office, have recently been set up by Mr. G. King, Burgh Surveyor, Lossiemouth, Morayshire, by Mr. J. Edwards Moss at Strathy (Bowside Lodge), Sutherland, and by the Galloway Water Power Co. at their Tongland Power Station, Kirkcudbright. The latter company had already a climatological station at Glenlee where observations commenced on January 1st, 1937. In view of the sparseness of stations in the northern mainland districts of Scotland, the establishment of the new station at Strathy is particularly to be welcomed.

REVIEW

The Weather of India. By C. W. B. Normand, C.I.E., M.A., D.Sc. Reprinted from " An outline of the field sciences in India." Calcutta, Ind. Sci. Congr. Ass., 1937. Pp. 16.

This is a short but very readable account of the meteorological conditions prevailing in the different parts of India through the year and its illustrations are particularly vivid and helpful. We note with interest that some of the winter depressions after leaving north India have been traced into China, and are curious enough to study the chart of mean annual rainfall to see how far recent records of hill stations on the western Ghats and in south Burma have produced rivals to Cherrapunji. The chart of cyclone tracks shows how small a vertical component of the rotation of the earth is necessary for their production ; one cyclone is shown as forming in lat. 6°N. and many begin to the south of lat. 10'N. G. T. WALKER.

The Weather of October, 1938

Mean pressure for the month exceeded 1020 mb. over the eastern Atlantic west of Spain, reaching 1024 mb. near the Azores, which was 5 mb. above the normal. Northwards from the Azores the mean pressure decreased rapidly to below 990 mb. in Iceland, the mean of 989 mb. at Reykjavik being 15 mb. below normal. Over Greenland, the British Isles and Scandinavia pressure was also below normal, the deficit reaching 10 mb. at Myggbukta and Lerwick ; elsewhere in Europe pressure was near the normal. No data were received from Russia or Siberia. In North America, mean pressure was near the normal over the United States, being above 1015 mb. everywhere and exceeding 1020 mb. at Nashville ; it decreased to below 1005 mb. over Alaska where it was 5 mb. below normal.

Temperature was generally slightly above normal ; the excess reached 7° to 9° F. in northern Scandinavia and 9° to 12° F. in north-west Canada. Mean temperature was over 80° F. in Anglo-Egyptian Sudan and reached nearly 90° F. at Khartoum ; it was slightly over 70° F. on the northern coast of Africa, over 60° F. in southern Europe, over 50° in France, much of central Europe, Ireland and most of

England, and it decreased to 40° F. in the extreme north of Scandinavia. In North America the mean temperature decreased northwards from over 70° F. in the extreme south of the United States to below 30° F. in the extreme north of Canada and Alaska.

The rainfall was rather variable. It was below normal in Italy, France and southern England, but it was excessive in parts of Ireland, Scotland, Sweden and the Baltic States, where in many places the fall for the month was double the average. In North America, with local exceptions, the amounts were generally below normal expecially in the Gulf States.

Over the British Isles the weather of the month was notable for the excessive rainfall in the west and north and the widespread, severe gales of the 3rd to 4th. Rainfall exceeded twice the average over large parts of Scotland, Ireland, north-west England and locally in north Wales; at Birr Castle the total equalled that of October, 1870, the previous highest there for October. Less than the average occurred at numerous places south-east of a line drawn roughly from the Humber to south Devon. From information at present available it appears that sunshine was below the average in most of Ireland and parts of north and west Scotland and of western England, but exceeded the average on the whole in the eastern half of Great Britain and the Midlands. Mean temperature somewhat exceeded the average generally but was about or a little below the average in the south-east.

Between the 2nd and 5th depressions moved north-east over Scotland; very unsettled weather prevailed with gales and heavy rain at times and local thunderstorms. The disturbance which crossed Scotland during the early hours of the 4th was very intense and caused widespread and severe gales; a wind speed of 104 mi/hr. was registered in a gust at Pembroke; considerable damage occurred and some loss of life. From the 6th to the 18th the tracks of the main depressions lay to the northward of Scotland, while associated secondary depressions passed across the British Isles. Gales were reported locally in the west and north on most days, while rain occurred frequently and was heavy at times. Local thunderstorms occurred between the 4th and 7th and on the 10th and 12th. Large daily falls of rain were numerous, particularly on the 2nd, 3rd, 5th, 6th, 8th and 12th; among the heaviest were 3·20 in. at New Dungeon Ghyll, Westmorland, and 2·99 in. at Borrowdale, Cumberland, on the 2nd; 3·86 in. at Borrowdale and 3·60 in. at New Dungeon Ghyll on the 3rd; 3·49 in. at Borrowdale on the 6th; 2·91 in. at Borrowdale and 2·90 in. at Blaenau Festiniog, Merioneth on the 8th, and 3·80 in. at Blaenau Festiniog, 2·89 in. at Ystalyfera, Glamorganshire, and 2·21 in. at Oughtershaw, Yorkshire, on the 12th.

On the 19th and 20th a wedge of high pressure moved eastward over the country and subsequently an anticyclone was established over the Baltic region; over most of England fair weather prevailed, apart from fog, until the 25th. In the west and north, however, conditions were mainly unsettled. A good deal of fog developed in England on the 20th and from the 22nd to 25th. Rainfall was rather heavy in Ireland on the 21st. Sharp frost occurred locally in south-east and east England on the 25th; a screen minimum of 25° F. was registered at Rothamsted and Tunbridge Wells.

On the 26th a depression near the Faeroes moved south-south-east giving rain in most parts on the 26th and 27th, and on the 30th and 31st secondary depressions associated with a disturbance near Iceland moved eastward over the country and caused further rain which was heavy locally on the 31st.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway ..	81	+ 4	Chester ..	102	+11
Aberdeen ..	110	+16	Ross-on-Wye	101	+ 2
Dublin	100	+ 2	Falmouth ..	121	+ 8
Birr Castle ..	68	−22	Gorleston ..	126	+11
Valentia ..	77	−13	Kew.. ..	111	+15

Kew temperature, mean, 51·1°F.: diff. from average, −0·5°F.

Miscellaneous Notes on Weather Abroad

Severe storms swept across France and the Low Countries on the 4th October causing much damage to trees and telegraph poles and disorganizing shipping in the Channel. A hurricane, accompanied by low temperatures, was reported from the Black Sea area on the 21st. Low lying parts of the coast were inundated and snow fell in the mountains in Bulgaria, three persons dying of cold. A tornado struck Limassol, Cyprus on the 23rd, and telephone and lighting services were interrupted. Snow fell in the Alps down to 4,000 ft. on the 27th, and many passes were closed to vehicles. Heavy floods following storm rains were reported from western India in the early part of the month, 15 persons were drowned and several houses collapsed in the Bombay suburbs. 500 people were killed and many hundreds injured during typhoons which swept across Japan on the 15th and 21st. The Osumi Peninsula and the lower parts of Tokyo were flooded, over 25,000 houses being inundated, and all sailings from Yokohama were suspended. High temperatures were recorded in New York in the middle of the month, 86° F. being reported on the 17th: at the same time the New England coast experienced thick fog which stopped all sea and air travel. Five people lost their lives and many were injured in floods which followed a rainstorm in Grenada on the 29th. Valuable rains fell in the pastural and agricultural districts of South Australia during the latter part of the month, breaking the drought which had held for many months and thus saving the harvest. (*The Times*—various dates.)

ERRATA

Climatological Tables, 1938

Kaduna, Pressure.	Jan.	*For*	1012·2	*read*	1011·6.
	Feb.	„	1012·2	„	1011·5.
	Mar.	„	1009·6	„	1008·9.

Daily Readings at Kew Observatory, October, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain	Sun	REMARKS
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1016·1	WNW.3	49	61	56	0·03	3·4	ir$_0$–r 7h.–9h.
2	1002·3	SSW. 3	49	57	90	0·17	1·2	ir$_0$ 5h.–8h., r^0 10h.–
3	1005·3	SW. 5	44	58	67	0·40	4·5	r–r$_0$ 16h.–23h. [14h.
4	996·7	WSW. 5	51	60	48	0·02	6·6	r$_0$ 7h. & 19h.–20h.
5	998·5	SSW. 3	51	55	87	0·13	0·3	r$_0$ 8h., r–r$_0$ 12h.–16h.
6	1012·5	WSW. 3	46	58	51	—	7·2	
7	1000·4	W. 4	50	58	87	0·13	0·1	d$_0$–r 8h.–14h.
8	1016·7	SW. 3	48	59	63	0·04	3·8	d$_0$–r 15h.–18h.
9	1002·1	SW. 4	52	64	68	0·22	0·1	r–r$_0$ 3h.–9h.
10	1010·7	SW. 3	47	58	66	—	2·1	
11	1017·9	SW. 4	43	59	59	—	5·9	
12	1022·3	SW. 4	46	60	69	0·04	1·6	r$_0$ 17h.–18h. & 23h.
13	1014·5	SW. 5	55	61	88	0·17	0·0	ir$_0$–r 5h.–10h.
14	1021·1	W. 3	51	60	54	—	8·0	
15	1021·3	SSW. 3	46	58	67	trace	4·7	ir$_0$ 20h.
16	1011·8	SSW. 3	49	61	86	0·28	0·0	ir$_0$–r 3h.–9h., d$_0$ 16h.
17	1012·1	SSW. 4	50	61	66	—	7·5	
18	1008·4	SSW. 3	52	60	71	0·08	3·8	ir$_0$–r 2h.–4h., d$_0$ 13h.
19	1022·1	W. 3	50	57	53	—	6·6	f 21h.–24h.
20	1027·4	S. 2	39	59	76	—	4·4	F till 10h.
21	1023·1	SE. 3	43	59	49	—	8·7	m 9h.
22	1011·2	SSE. 3	42	54	74	—	7·0	f–F 20h.–24h.
23	1014·1	E. 2	41	56	71	—	4·5	F–f 0h.–12h., F 21h.–
24	1019·5	W. 1	34	51	88	—	1·9	F–f 0h.–24h. [24h.
25	1013·0	W. 1	32	49	94	—	1·7	F–f 0h.–24h.
26	1010·7	NW. 3	36	53	54	0·22	4·6	r–r$_0$ 2h.–5h., 18h.–23h.
27	1006·0	NW. 2	38	48	67	0·06	4·0	r$_0$ 3h.–5h. & 22h.–24h.
28	1015·1	N. 3	45	53	62	—	3·7	f 21h.–24h.
29	1014·2	Calm	39	53	67	—	2·7	f 9h. & 16h.–17h.
30	1007·7	S. 2	44	56	89	0·07	0·0	id$_0$–r 9h.–19h.
31	1015·4	SW. 3	39	53	72	—	0·3	
*	1012·6	—	45	57	70	2·06	3·6	*Means or Totals.

General Rainfall for October, 1938

England and Wales	126	per cent of the average 1881–1915.
Scotland	186	
Ireland	193	
British Isles ...	154	

Rainfall : October, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
Lond .	Camden Square..........	2·72	103	*War* ·	Birminghm, Edgbaston	2·67	96
Sur .	Reigate, Wray Pk. Rd..	3·46	104	*Leics* .	Thornton Reservoir ...	2·52	90
Kent .	Tenterden, Ashenden...	3·62	104	,, .	Belvoir Castle............	2·07	77
,, .	Folkestone, I. Hospital.	3·35	...	*Rut* .	Ridlington	2·19	78
,, .	Margate, Cliftonville....	2·56	88	*Lincs* .	Boston, Skirbeck.........	2·25	82
,, .	Eden'bdg., Falconhurst	3·79	105	,, .	Cranwell Aerodrome...	1·91	67
Sus .	Compton, Compton Ho.	5·34	117	,, .	Skegness, Marine Gdns.	1·90	69
,, .	Patching Farm..........	4·05	102	,, .	Louth, Westgate.........	3·05	94
,, .	Eastbourne, Wil. Sq....	3·99	96	,, .	Brigg, Wrawby St.......	2·71	...
Hants.	Ventnor, Roy.Nat.Hos.	4·50	114	*Notts* .	Mansfield, Carr Bank...	3·18	105
,, .	Southampton,East Park	3·65	93	*Derby*.	Derby, The Arboretum	2·48	91
,, .	Ovington Rectory.......	3·70	91	,, .	Buxton, Terrace Slopes	7·53	153
,, .	Sherborne St. John......	3·87	110	*Ches* .	Bidston Obsy.............	4·01	123
Herts .	Royston,Therfield Rec.	2·67	98	*Lancs*.	Manchester, Whit. Pk.	6·15	186
Bucks.	Slough, Upton............	2·50	89	,, .	Stonyhurst College......	10·69	238
Oxf .	Oxford, Radcliffe.........	2·84	98	,, .	Southport, Bedford Pk.	6·93	196
N'hant	Wellingboro, Swanspool	2·68	106	,, .	Ulverston, Poaka Beck	10·81	195
,, .	Oundle	1·74	...	,, .	Lancaster, Greg Obsy.	9·53	232
Beds .	Woburn, Exptl. Farm...	2·88	108	,, .	Blackpool	7·19	193
Cam .	Cambridge, Bot. Gdns.	2·47	105	*Yorks*.	Wath-upon-Dearne......	2·89	104
,, .	March.......................	2·20	85	,, .	Wakefield,Clarence Pk.	3·54	123
Essex.	Chelmsford,County Gdns	2·55	104	,, .	Oughtershaw Hall.......	18·81	...
,, .	Lexden Hill House......	2·63	...	,, .	Wetherby, Ribston H..	...	...
Suff .	Haughley House.........	2·45	...	,, .	Hull, Pearson Park......	2·96	99
,, .	Rendlesham Hall........	3·19	123	,, .	Holme-on-Spalding......	3·47	116
,, .	Lowestoft Sec. School...	2·59	93	,, .	Felixkirk, Mt. St. John.	3·74	130
,, .	Bury St. Ed., WestleyH.	2·79	103	,, .	York, Museum...........	3·15	117
Norf. .	Wells, Holkham Hall...	2·53	90	,, .	Pickering, Houndgate...	4·04	132
Wilts .	Porton, W.D. Exp'l. Stn	2·69	86	,, .	Scarborough..............	3·40	109
,, .	Bishops Cannings........	4·51	136	,, .	Middlesbrough...........	3·08	103
Dor .	Weymouth, Westham.	3·40	93	,, .	Baldersdale, Hury Res.	8·37	210
,, .	Beaminster, East St....	5·01	113	*Durh* .	Ushaw College...........	3·47	101
,, .	Shaftesbury..............	2·35	60	*Nor* .	Newcastle, Leazes Pk...	3·58	116
Devon.	Plymouth, The Hoe....	3·92	99	,, .	Bellingham, Highgreen	6·01	153
,, .	Holne, Church Pk. Cott.	9·20	139	,, .	Lilburn Tower Gdns....	5·22	141
,, .	Teignmouth, Den Gdns.	2·83	73	*Cumb*.	Carlisle, Scaleby Hall...	7·35	220
,, .	Cullompton	3·48	84	,, .	Borrowdale, Seathwaite	29·25	257
,, .	Sidmouth, U.D.C........	2·81	...	,, .	Thirlmere, Dale Head H.	20·98	235
,, .	Barnstaple, N. Dev.Ath	5·04	111	,, .	Keswick, High Hill......	16·99	303
,, .	Dartm'r,Cranmere Pool	9·90	...	,, .	Ravenglass, The Grove	8·48	196
,, .	Okehampton, Uplands.	7·42	123	*West* .	Appleby, Castle Bank...	7·73	222
Corn .	Redruth, Trewirgie......	...	...	*Mon* .	Abergavenny, Larchf'd	4·21	100
,, .	Penzance, Morrab Gdns.	5·04	108	*Glam* .	Ystalyfera, Wern Ho....	13·00	189
,, .	St. Austell, Trevarna...	5·07	96	,, .	Treherbert, Tynywaun.	15·78	...
Soms .	Chewton Mendip.........	8·38	174	,, .	Cardiff, Penylan..........	8·15	172
,, .	Long Ashton............	5·92	157	*Carm* .	Carmarthen,M. & P. Sch.	11·24	190
,, .	Street, Millfield..........	2·84	89	*Card* .	Aberystwyth	6·30	...
Glos .	Blockley	2·99	...	*Rad* .	BirmW.W.Tyrmynydd	9·31	141
,, .	Cirencester, Gwynfa....	4·17	126	*Mont* .	Lake Vyrnwy	14·27	251
Here .	Ross-on-Wye.............	2·78	84	*Flint* .	Sealand Aerodrome......	3·07	105
,, ·	Kington, Lynhales.......	4·40	117	*Mer* .	Blaenau Festiniog	20·63	221
Salop.	Church Stretton.........	4·38	121	,, .	Dolgelley, Bontddu......	8·06	133
,, .	Shifnal, Hatton Grange	2·60	92	*Carn* ·	Llandudno	4·24	126
,, .	Cheswardine Hall........	3·36	108	,, .	Snowdon, L. Llydaw 9..	30·30	...
Worc .	Malvern, Free Library...	2·54	85	*Ang* .	Holyhead, Salt Island...	6·62	166
,, .	Ombersley, Holt Lock.	2·04	76	,, .	Lligwy	8·88	...
War .	Alcester, Ragley Hall...	2·63	96	*I. Man*	Douglas, Boro' Cem....	9·00	198

Erratum: Folkestone, Borough Sanatorium, September, *for* 1·91 read 2·22 inches.

Rainfall: October, 1938: Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.
Guern.	St.Peter P't.Grange Rd.	3.88	86
Wig	Pt. William, Monreith.	7·67	194
,,	New Luce School	9·15	196
Kirk	Dalry, Glendarroch	9·45	180
Dumf.	Eskdalemuir Obs.	10·98	203
Roxb	Hawick, Wolfelee	6·21	162
,,	Kelso, Broomlands	4·23	145
Peeb	Stobo Castle	6·51	189
Berw	Marchmont House	5·16	135
E.Lot.	North Berwick Res.	4·78	161
Midl	Edinburgh, Blackfd. H.	4·50	164
Lan	Auchtyfardle	7·51	...
Ayr	Kilmarnock, Kay Park	10·37	...
,,	Girvan, Pinmore	7·84	157
,,	Glen Afton, Ayr San.	11·14	218
Renf	Glasgow, Queen's Park	9·25	285
,,	Greenock, Prospect H.	11·72	231
Bute	Rothesay, Ardencraig	10·20	231
,,	Dougarie Lodge	11·70	283
Arg	Loch Sunart, G'dale	12·25	186
,,	Ardgour House	16·05	...
,,	Glen Etive	18·92	234
,,	Oban	10·70	...
,,	Poltalloch	10·34	210
,,	Inveraray Castle	25·59	321
,,	Islay, Eallabus	9·29	195
,,	Mull, Benmore	22·60	175
,,	Tiree	...	...
Kinr	Loch Leven Sluice	6·32	184
Fife	Leuchars Aerodrome	3·52	135
Perth	Loch Dhu	15·95	223
,,	Crieff, Strathearn Hyd.	7·06	180
,,	Blair Castle Gardens	6·50	210
Angus.	Kettins School	4·25	134
,,	Pearsie House	4·75	...
,,	Montrose, Sunnyside	3·54	128
Aber	Balmoral Castle Gdns.	4·21	117
,,	Logie Coldstone Sch.	3·68	114
,,	Aberdeen Observatory.	2·96	99
,,	New Deer School House	3·57	94
Moray	Gordon Castle	2·28	72
,,	Grantown-on-Spey	4·80	162
Nairn.	Nairn	3·65	155
Inv's	Ben Alder Lodge	10·88	...
,,	Kingussie, The Birches	7·10	...
,,	Loch Ness, Foyers	7·50	223
,,	Inverness, Culduthel R.	4·59	187
,,	Loch Quoich, Loan	23·40	...
,,	Glenquoich	20·49	205
,,	Arisaig House	11·77	200
,,	Glenleven, Corrour	13·24	217
,,	Fort William, Glasdrum	14·61	...
,,	Skye, Dunvegan	14·98	...
,,	Barra, Skallary	8·54	...
R&C.	Tain, Ardlarach	5·00	165
,,	Ullapool	10·32	213
,,	Achnashellach	15·47	193
R&C	Stornoway,C.GuardStn.	8·66	176
Suth	Lairg	8·58	230
,,	Skerray Borgie	6·81	...
,,	Melvich	6·53	178
,,	Loch More, Achfary	13·59	174
Caith	Wick	4·45	150
Ork	Deerness	6·35	168
Shet	Lerwick Observatory	6·91	174
Cork	Cork, University Coll.	4·84	124
,,	Roches Point, C.G. Stn.	4·80	117
,,	Mallow, Longueville	5·68	158
Kerry.	Valentia Observatory	7·51	135
,,	Gearhameen	14·70	160
,,	Bally McElligott Rec.	6·35	...
,,	Darrynane Abbey	7·11	141
Wat	Waterford, Gortmore	4·96	127
Tip	Nenagh, Castle Lough.	9·78	288
,,	Cashel, Ballinamona	6·11	172
Lim	Foynes, Coolnanes	6·32	167
,,	Limerick, Mulgrave St.	8·24	237
Clare	Inagh, Mount Callan	12·45	...
Wexf	Gorey, Courtown Ho.	4·53	122
Wick	Rathnew, Clonmannon.	5·07	...
Carl	Bagnalstown,Fenagh H.	5·01	150
,,	Hacketstown Rectory	6·79	179
Leix	Blandsfort House	5·82	165
Offaly.	Birr Castle	7·28	250
Kild	Straffan House	6·31	222
Dublin	Dublin, Phoenix Park	5·55	210
Meath.	Kells, Headfort	7·19	215
W.M	Moate, Coolatore	6·02	...
,,	Mullingar, Belvedere	8·66	278
Long	Castle Forbes Gdns.	7·85	241
Gal	Galway, Grammar Sch.	6·07	163
,,	Ballynahinch Castle	11·97	200
,,	Ahascragh, Clonbrock.	7·96	218
Rosc	Strokestown, C'node	6·46	212
Mayo.	Blacksod Point	7·62	153
,,	Mallaranny	11·09	...
,,	Westport House	7·06	157
,,	Delphi Lodge	14·54	153
Sligo	Markree Castle	8·08	197
Cavan.	Crossdoney, Kevit Cas.	7·77	...
Ferm	Crom Castle	8·33	256
Arm	Armagh Obsy	5·49	202
Down.	Fofanny Reservoir	10·79	...
,,	Seaforde	6·33	178
,,	Donaghadee, C. G. Stn.	5·31	184
Antr	Belfast,Queen's Univ.	7·75	236
,,	Aldergrove Aerodrome.	5·74	191
,,	Ballymena, Harryville.	7·34	199
Lon	Garvagh, Moneydig	7·17	...
,,	Londonderry, Creggan.	8·22	223
Tyr	Omagh, Edenfel	7·53	205
Don	Malin Head	7·07	184
,,	Dunfanaghy	5·90	152
,,	Dunkineely	8·16	...

Climatological Table for the British Empire, May, 1938

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
	Mean of Day M.S.L.	Diff. from Normal.	Absolute.		Mean Values.				Mean			Am'nt.	Diff. from Normal.	Days	Hours per day.	Percentage of possible.
			Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.							
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1014·8	− 1·1	75	32	60·3	44·8	52·5	− 2·0	46·8	76	7·4	1·30	− 0·42	13	5·2	34
Gibraltar	1016·1	0·0	80	51	68·2	56·7	62·5	− 3·0	55·2	74	4·2	2·63	...	7	...	...
Malta	1015·6	+ 1·1	75	55	68·1	58·6	63·3	− 2·6	58·8	77	4·6	0·46	+ 0·05	5	10·5	75
St. Helena	1016·7	− 1·5	70	56	67·1	59·4	63·3	+ 1·0	60·4	87	7·4	1·65	− 1·03	11	...	...
Freetown, Sierra Leone	1011·6	+ 2·1	90	71	86·3	74·4	80·3	...	75·6	79	6·8	9·58	− 1·89	17	...	...
Lagos, Nigeria	1010·9	+ 0·3	91	70	86·2	74·5	80·3	− 1·5	76·7	87	6·5	10·87	+ 0·12	15	5·5	44
Kaduna, Nigeria	1009·5	...	95	64	89·1	71·7	80·4	+ 0·5	72·6	81	8·3	6·92	+ 1·15	15	7·7	61
Zomba, Nyasaland	1014·1	− 1·3	84	53	76·5	57·5	67·0	+ 1·2	64·7	85	3·5	1·12	+ 0·08	4	...	...
Salisbury, Rhodesia	1016·5	− 1·1	81	40	75·3	48·5	61·9	+ 1·3	53·8	54	0·9	0·01	...	1	9·8	87
Cape Town	1017·6	− 0·5	80	43	67·1	53·0	60·1	+ 1·2	53·5	82	5·5	4·79	+ 1·04	16	...	...
Johannesburg	1017·3	− 0·8	76	35	66·6	47·8	57·2	+ 2·8	46·7	58	2·0	0·36	− 0·40	2	8·7	80
Mauritius	1015·6	− 0·7	84	62	80·1	67·3	73·7	+ 1·1	70·5	76	4·4	3·12	− 0·80	17	8·0	71
Calcutta, Alipore Obsy.	1000·7	− 2·8	100	69	93·1	77·1	85·1	− 1·0	79·2	84	7·3	14·54	+ 8·98	14*	...	...
Bombay	1005·2	− 2·2	94	78	91·9	80·9	86·4	+ 0·6	78·3	74	3·8	1·29	+ 0·74	3*	...	...
Madras	1002·9	− 2·5	108	76	101·0	82·8	91·9	+ 2·1	77·8	58	5·4	0·12	− 1·72	1*	...	...
Colombo, Ceylon	1007·9	− 0·5	89	75	87·1	79·5	83·3	+ 0·5	79·1	78	7·0	3·48	− 7·46	18	6·5	52
Singapore	1008·7	0·0	90	73	86·7	75·6	81·1	− 0·9	78·0	80	6·8	9·61	+ 2·97	19	5·7	47
Hongkong	1009·1	0·0	89	67	83·5	75·1	79·3	+ 1·9	75·5	82	7·9	8·71	− 3·36	14	5·2	40
Sandakan	1008·0	...	90	73	86·9	75·9	81·4	− 1·1	77·7	86	7·5	9·46	+ 3·13	14	...	...
Sydney, N.S.W.	1021·8	+ 3·2	77	45	68·4	54·2	61·3	+ 2·5	56·2	80	6·2	3·81	− 1·37	16	4·9	47
Melbourne	1021·5	+ 2·3	79	39	65·9	47·1	56·5	+ 2·4	50·4	76	6·5	0·78	− 1·38	10	4·3	42
Adelaide	1021·7	+ 1·5	77	41	67·9	50·8	59·3	+ 1·3	53·7	67	6·5	0·98	− 1·74	10	4·8	47
Perth, W. Australia	1017·1	− 1·3	80	45	69·5	52·8	61·1	+ 0·4	54·8	69	5·9	1·75	− 3·22	10	6·5	62
Coolgardie	1018·7	− 0·4	77	37	67·5	48·1	57·8	+ 0·1	52·1	77	5·3	0·76	− 0·57	4	...	...
Brisbane	1019·6	+ 1·0	83	54	73·6	60·1	66·9	+ 2·3	62·0	80	5·7	11·81	+ 9·00	11	5·1	47
Hobart, Tasmania	1018·6	+ 3·3	66	39	59·4	45·4	52·4	+ 1·9	47·2	77	5·5	1·15	− 0·75	11	4·9	51
Wellington, N.Z.	1020·2	+ 4·6	66	40	60·3	48·5	54·4	+ 1·6	52·0	79	6·2	0·87	− 3·81	11	5·5	56
Suva, Fiji	1012·8	+ 0·1	87	63	82·5	73·0	77·7	+ 1·2	73·0	82	6·3	11·58	+ 1·51	22	3·7	33
Apia, Samoa	1010·4	− 0·7	87	71	84·9	74·2	79·5	+ 1·1	75·8	79	5·0	8·79	+ 2·72	19	6·8	59
Kingston, Jamaica	1013·5	+ 0·4	90	69	87·4	72·3	79·9	+ 0·2	71·3	74	3·0	0·60	− 3·79	5	6·6	51
Grenada, W.I.	1011·1	− 1·5	88	71	86	73	79·5	− 0·2	74	78	7	12·91	+ 8·72	23	...	...
Toronto	1013·9	− 1·0	78	36	63·9	46·4	55·1	+ 1·3	46·8	67	5·6	2·15	− 0·64	10	7·0	48
Winnipeg	1013·3	− 0·5	79	27	63·0	40·7	51·9	− 0·1	41·0	83	6·3	1·60	− 0·40	10	6·5	42
St. John, N.B.	1012·9	− 1·0	69	33	56·3	40·1	48·2	+ 0·5	43·0	77	7·0	3·35	− 0·36	16	6·6	44
Victoria, B.C.	1019·6	+ 2·9	73	39	60·1	46·0	53·1	+ 0·1	49·4	74	4·9	0·54	− 0·59	6	10·8	71

* For Indian stations a rain day is a day on which 0·1 in. or more rain has fallen.

(44465) Wt. 21/31 1250 11/38 Hw. G.377/6

Frontispiece]

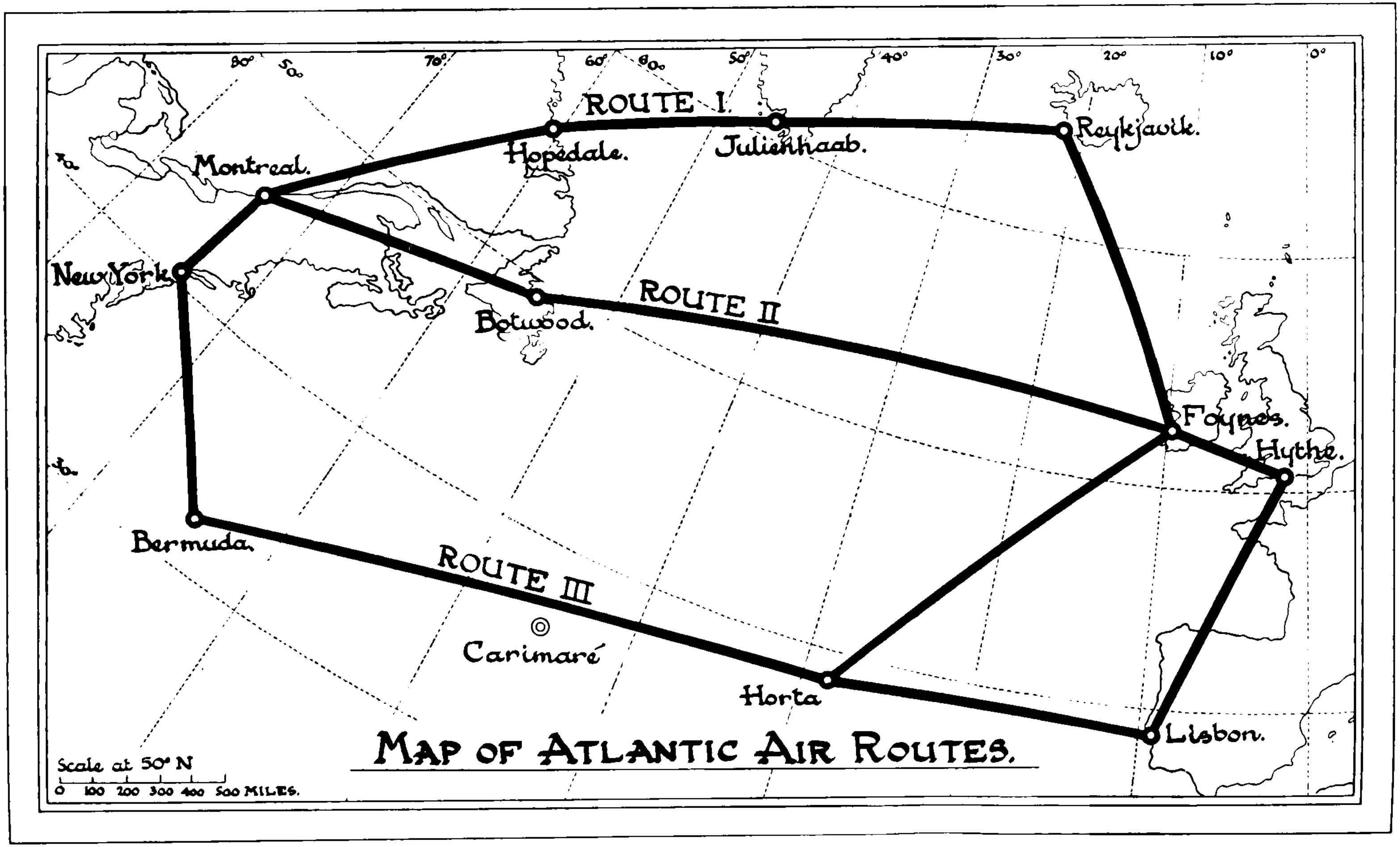
MAP OF ATLANTIC AIR ROUTES.
ROUTE I.
ROUTE II
ROUTE III
Montreal.
Hopedale.
Julienhaab.
Reykjavik.
New York.
Botwood.
Foynes.
Hythe.
Bermuda.
Carimaré
Horta
Lisbon.
80°
70°
60°
50°
40°
30°
20°
10°
0°
Scale at 50° N
0 100 200 300 400 500 MILES.

FIGURE I

M.O. 422.

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THE METEOROLOGICAL PROBLEM OF THE NORTH ATLANTIC

By F. Entwistle, B.Sc.

(*Summary of Lecture delivered before the Royal Aeronautical Society, on November 3rd,* 1938.)

Meteorology has always been regarded as an essential adjunct to the safe, regular and economical operation of an air route but whereas, along the shorter overland routes, such as those which form a close network over Europe, radio direction-finding stations and blind flying equipment have resulted in pilots being able to fly largely independent of weather conditions (apart from the danger of ice accretion and the weather at the terminals), meteorology has become an increasingly important factor in the operation of trans-ocean routes. In addition to the risk of overlong flying times, due to unexpected head winds, an error in wind estimation might result in the aircraft drifting badly off its course in several hours. Direction-finding assistance, both from shore stations and from ships, is of considerable importance but over long ranges a comparatively small error in bearings can produce a dangerously large position error. It follows, therefore, that meteorology enters into the problem of *navigation* over long trans-ocean routes, accurate wind forecasts being of great importance.

Over the North Atlantic there are three alternative routes: the northern route via Iceland, Greenland and Labrador; the direct route via Ireland and Newfoundland; and the southern route via the Azores and Bermuda. The northern route has a maximum stage of 900 miles but both the others entail non-stop flights of 2,000 miles (figure 1). The choice of a particular route depends largely on the meteorological conditions at possible air bases and refuelling stops as well as those along the route itself. On the northern and direct routes the main meteorological considerations are fog, snow, ice accretion and the freezing of harbours in winter. These considerations preclude the operation of either of these routes by flying boats except during the summer half-year. Provided, however, that it is found possible to keep the runways at the Newfoundland airport clear of snow in winter, and the ice accretion problem can be overcome, it should be possible to operate the direct route with landplanes throughout the year. The southern route experiences better weather conditions than either of the other two routes but investigation has shown the Azores to be devoid of any flying boat base suitable for operation under all conditions of wind and weather. Unless this difficulty can be surmounted, it may be found that the only feasible means of operating the southern route is by landplanes, in which case the direct route, being shorter, would be preferable.

SUMMARY OF TIMES OF PASSAGE AND GROUND SPEEDS OF TRANS-ATLANTIC AIRCRAFT WITH AIR SPEED OF 150 M.P.H.

Route.	I.	II.		III.	
	Foynes to New York *via* Greenland.	Foynes to New York *via* Botwood.	Section Foynes to Botwood.	Foynes to New York *via* Azores.	Section Azores to Bermuda
Average of all times of passage (hrs.)	24·7	23·4	14·8	30·5	15·1
Corresponding ground speed (mi/hr.)	146	137	135	137	136
Average head wind (mi/hr.)...	4	13	15	13	14
Shortest time (hrs.)	18·6	17·6	10·0	22·7	11·1
Corresponding ground speed (mi/hr.)	194	177	200	184	185
Average following wind (mi/hr.)	44	27	50	34	35
Longest time (hrs.)	31·4	32·6	22·2	41·3	21·8
Corresponding ground speed (mi/hr.)	115	98	90	101	89
Average head wind (mi/hr.)	35	52	60	49	61
Percentage number of occasions corresponding to head wind of more than 40 mi/hr.	—	1·2	2·8	0·9	2·3
Number of days a year ...	—	4	10	2	8

The prevailing westerly winds over the North Atlantic, which attain their maximum speed in winter, stand out, however, as a predominating influence in the operation of any route in an east-west direction. The more important results of an investigation into the times of passage of an aircraft cruising at 150 mi/hr. along the three routes from east to west are shown in the accompanying table. The northern route stands out as being the best from the point of view of wind, the average head wind being only 4 mi/hr. A remarkable feature of the other two routes is the close agreement between the two long trans-ocean sections, Foynes–Botwood and Azores–Bermuda, the average head wind over these sections being of the order of 15 mi/hr. and the average maximum head wind 60 mi/hr. An average head wind exceeding 40 mi/hr. would be experienced on only 10 days a year on the direct route and on 8 days a year on the southern route. These data have an important bearing on the design of aircraft for the operation of a trans-Atlantic air route.

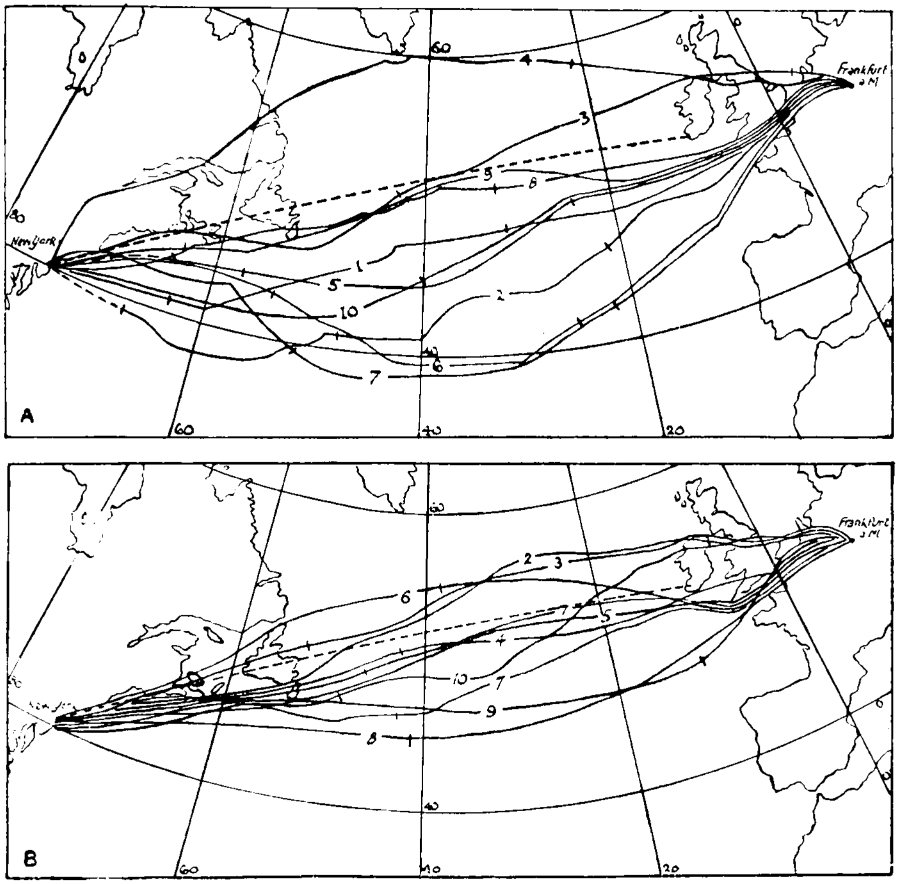

FIG. 2. MAPS SHOWING COURSES FOLLOWED BY THE AIRSHIP *Hindenburg* BETWEEN FRANKFORT AND NEW YORK, MAY TO OCTOBER, 1936.
A. OUTWARD FLIGHTS. B. RETURN FLIGHTS.

The specialised meteorological organisation which has been drawn up for flights on the direct route involves close co-operation between the forecasting centres at the Shannon and Botwood terminals, both of which draw weather charts, covering the North Atlantic and adjacent continental areas, at six-hourly intervals, from data disseminated in accordance with international arrangements. The information supplied to Commanders of aircraft before departure and during flight is based on the analysis of these charts. The organisation, a detailed description of which space will not allow, has been devised to provide essential safeguards and the maximum help to navigation which is possible.

An example of the application of meteorological information to navigating over the ocean is shown by the charts in figure 2 which indicate the courses followed by the ill-fated airship *Hindenburg* during 1936. It can be seen that the outward flights showed considerably greater deviation from the direct track than those on the return journey. An outstanding case was that of the fourth flight in which the airship flew across the north of Ireland to just south of Greenland and thence via Labrador to New York, in order to take advantage of the easterly winds to the north of a low-pressure area lying over the North Atlantic. This flight actually proved to be the fastest of the series. Although such deviations are more practicable in the case of an airship, the Imperial Airways flying boat *Caledonia*, during a trans-Atlantic flight in 1937, made a somewhat similar deviation to avoid strong head winds, and thereby saved, in the estimation of the Commander, about two and a half hours flying time.

It is equally important, from the point of view of saving time and economising fuel, to take advantage of the variation of wind with height. Here the trans-Atlantic pilot is somewhat handicapped at present, owing to the difficulty of arranging for upper wind observations over the ocean. Apart from the possibility of equipping certain ocean-going liners with pilot balloon apparatus, a solution to this problem appears to be the establishment of a stationary meteorological ship in mid-Atlantic. The experience gained with the French ship *Carimaré*, which was stationed between the Azores and Bermuda in the summers of 1937 and 1938, showed that considerable help to trans-Atlantic flying can be secured in this way. The meteorological staff of the *Carimaré* made regular surface, pilot balloon and radio-sonde observations, and collected observations from ships which would not otherwise have been received, in addition to the regular meteorological collective messages issued from both Continents. By this means complete weather charts of the North Atlantic were prepared. The ship was also fitted with radio direction-finding equipment. The value of such a ship on the direct North-Atlantic route, about mid-way between Ireland and Newfoundland cannot be over-estimated. Apart from providing direct aids to navigation, it would supply data, particularly upper air information, which would ensure a more detailed analysis of the Atlantic weather situation and so improve the value of the information supplied to the flying services.

Estimating the Remoteness of Observed Cloud Features

By H. H. Lamb.

Visibility is normally better in the free air than near the earth's surface. The light rays whereby one sees distant cirrus, altostratus or tall cumulus, pass for most of the distance through layers of the atmosphere far above any surface haze. In the account of Watkins' 1930 Greenland expedition a case is mentioned where cumulus clouds were seen beyond a headland known to be 250 miles away. Inasmuch as the observation was made from an aircraft, this gives an unfair idea of the clearness of polar air in its source region when compared with surface observations of visibility in other parts of the world. Probably it is not uncommon for clouds of sufficient height to be seen from over 100 miles away in most parts of the British Isles. Indeed Mr. C. S. Durst, after seeing from near Bedford a rift in the sky over Cardigan Bay at sunset, discussed this aspect of the subject in an earlier paper in the *Meteorological Magazine*.*

There must therefore be occasions on which a knowledge of the distance away of observed features of the visible sky would help in interpreting the weather map, and give a continuity to the weather reports from the surrounding stations situated underneath the sky in sight. The line of a front might be deduced from the distances obtained for several points along the edge of its cloud-sheet, the movement of the front from successive observations through time of this edge. Such observations may be of particular value at coastal forecasting stations, where reports from the neighbouring sea are few, or when for any other reason reports from the vital direction are lacking. At Montrose, for instance, it has been found possible to place fronts even over the further side of the North Sea by this means, to forecast the advance of warm fronts and return of cold fronts from the seaward quarter. The method gives a better idea of the actual rate of advance of a front than can be got from the isobars on the weather map. On occasion it also serves to foretell the time of arrival of showers as cumulo-nimbus clouds approach or of a general clearance by watching the movement of far-off rifts in an overcast sky.

The angle of elevation of a cloud (ε) in terms of its height (H) above sea level and its distance away (D), both in miles is given by :—

$$\tan \varepsilon = \frac{2RH - D^2}{2RD}$$

where R is the radius of the earth in miles. The observations are taken to be made from sea level.

The curves shown in Fig. 1 are derived from this formula and drawn to a logarithmic scale of distance to give the angles of elevation of clouds at heights of 1, 2, 3, 4 or 5 miles seen from a station at sea level. Calculation shows that, if used at stations up to 500 feet above sea level, the curves will give an error in distance never more than 5 miles. The elevation error will be less than 1° except for low clouds near the station. Probably refraction effects produce as great an error, and the curves can fairly be used by any forecasting station in the British Isles.

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* *Meteorological Magazine*, 1928, page 241.

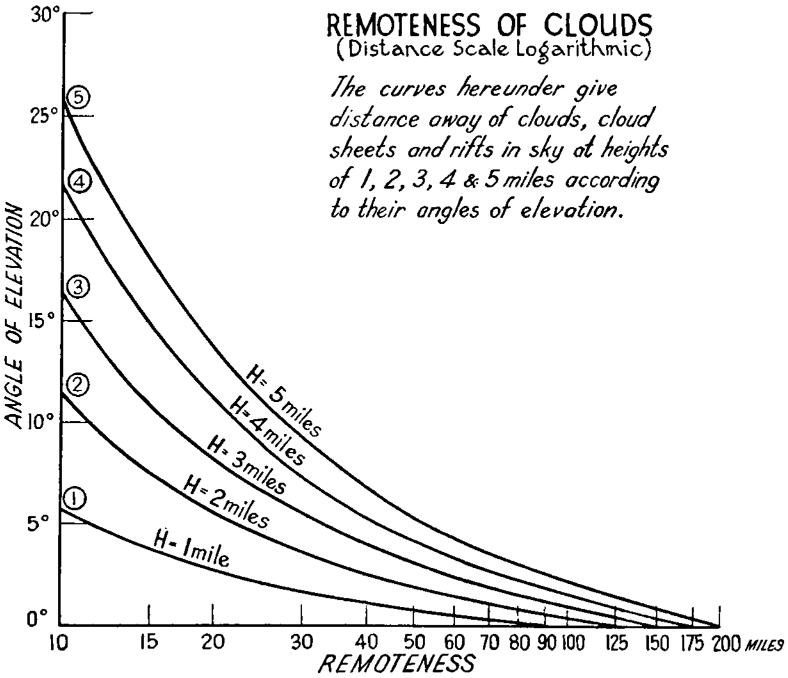


FIG.1

The curves can readily be used if displayed on the wall of the forecasting room. At stations which make pilot balloon observations with a theodolite it is only a moment's work to take the angle of elevation of a cloud feature (and its azimuthal direction). It remains to determine the height of the cloud feature observed. When cloud-sheets are continuous with cloud overhead, or which has lately passed overhead, it is often possible from pilot balloon observations to know the height rather accurately. But an experienced observer can usually tell the height of sheets of middle and high cloud to the nearest mile (no greater accuracy is required); whilst the tops of cumulus and cumulonimbus are estimated from their stage of development or by reference to where they pierce altocumulus layers.

Visibility on the West Somerset Coast

By T. F. Twist

The visibility conditions observed in the Bristol Channel on July 17th, 1937, and described in this Magazine for September, 1937, are of much interest. I should say from my experience (extending over more than 30 years) of the west Somerset coast that these conditions are far from uncommon, particularly during the summer months. I have never had the opportunity of seeing, as it were, a panoramic view of the conditions from the Welsh coast, but often have observed them both from the land at sea-level and the tops of the hills at over 1,000 feet, as well as from the sea on the Somerset side.

It seems that the relatively poor visibility over the sea is confined to within about 5 miles of the west Somerset and north Devon coast bordering the Exmoor country, as visibility in the low-lying land areas, such as occur at Porlock and between Minehead and Watchet, is quite good on these occasions, though the haze can be seen quite clearly out to sea from these points. From the hills it is possible to see over the top of the haze, and the coast and mountains of Wales are often very clear. The height of the haze naturally varies on different occasions, but seems usually to be between about 400 and 800 feet. The small cumulus-like clouds appear to be mainly in three overlapping lines, which would look from a distance such as from the Welsh coast, as one more or less continuous line of cloudlets. The points of origin of the lines are the Quantock Hills, the western portion of the North Hill near Minehead, and the Foreland near Lynmouth. These strings of cloudlets stretch away to windward from these points for six miles or more, as I have observed from boats while fishing.

These conditions only occur when the wind has veered from some southerly point to between west and west-north-west, the strength of the wind being usually about force 4. In the southerly current the visibility is usually good along the coast, except for deterioration caused by rain or drizzle.

It is noticed that the surface wind on the Glamorgan coast was west-south-west about 10 mi/hr. on July 17th; but on the Somerset side it was definitely west-north-west 15 mi/hr. or more and extended up to 800 feet at least, as I observed on the occasion in question. This veer and freshening of the wind along the west Somerset and north Devon coast is a common occurrence, while at a distance of five miles or so off-shore the wind backs and decreases in velocity. It is connected with the normal sea-breeze effect for this coast, augmented by deflection along the high coast line.

On July 17th the air behind the cold front was old maritime polar air which was probably fairly stable in its lowest layers owing to a long journey over the sea from the southward. In these conditions it would not differ greatly in its lowest layers from the air it was displacing as evidenced by its high humidity and by fog reported at Pembroke and Scilly after the passage of the cold front. It would, however, differ from the displaced air at higher levels above the relatively stratified portion at the bottom, and it seems that the haze may be due to mixing in this bottom portion of the air in the sea-breeze area, and the cloudlets at the top formed by the larger eddies under the influence of the ranges of hills mentioned above. The distance of influence of these hills, especially the Quantocks, is remarkable, but from observations taken at sea it appears that the cloudlets are definitely connected with the deflection of the air-stream by these hills.

OFFICIAL NOTICE

Discussions at the Meteorological Office

The meetings for the discussion of recent contributions to meteorological literature will be resumed at the Meteorological Office on January 16th, 1939. The meetings will be held on alternate Mondays, promptly at 5 p.m. Tea will be available from 4.30 p.m. The dates and subjects for discussion are as follows :—

January 16th.—(1) *The trade wind inversion.* By H. von Ficker. *Berlin, Veröff. Met. Inst. Univ.*, **1**, Heft 4, 1936, pp. 33. (2) *Note on the heat exchange within the trade wind circulation.* By H. von Ficker, *Berlin, Sitzb. Ak. Wiss. Phys. Math. Kl.* 1936, **XI**, pp. 103–114. (Both in German.) *Opener*, Prof. D. Brunt.

January 30th.—*Investigations of selected European cyclones by means of serial ascents. Case* 4, *Feb.* 15–17, 1935. By J. Bjerknes and E. Palmen. *Oslo, Geofys. Publ.*, 12, *No.* 2, 1937, pp. 62. *Opener*, Mr. J. Crichton.

February 13th.—(1) *A contribution to the study of weather processes in the Gulf of Mexico, in the Caribbean Sea and in the West Indies. Met. Zs.* **54**, 1937, *Teil I and II*, pp. 353–359, *Teil III*, pp. 413–417. (2) *On the origin of West Indian hurricanes. Met. Zs.* **55**, 1938, pp. 317–321. Both by H. Externbrink. (In German.) *Opener*, Mr. S. Proud.

February 27th.—*On high clouds.* By W. Schwerdtfeger. *Berlin, Wiss. Abh. Reichs Wetterd.* **5**, No. 1, 1938, pp. 34. (In German.) *Opener*, Mr. H. W. L. Absalom.

March 13th.—Subject to be announced later. *Opener*, Mr. G. R. Hay.

A meeting of the staff of the Meteorological Office only will be held on March 27th.

Royal Meteorological Society

A meeting of the Society was held on Wednesday, the 16th instant, in the Society's rooms at 49, Cromwell Road, South Kensington. Dr. J. Glasspoole, M.Sc., Vice-President, was in the Chair.

The following papers were read and discussed.

S. Mal, M.Sc., Ph.D., D.I.C., and B. N. Desai, B.A., LL.B., M.Sc., PH.D., F.R.S.E.—(i) *The mechanism of thundery conditions at Karachi.*

Weather conditions and aeroplane ascents at Karachi between June 22nd and July 2nd, 1936, have been examined for understanding the mechanism of thundery conditions which prevailed there during that period. It is observed that thundery conditions occurred when the characteristic monsoon inversion was absent and there was a sufficiently deep layer of air which when raised to a certain level either by insolation, arrival of sea air, or convergence of winds, released an appreciable amount of energy of latent instability.

G. Manley, M.A., B.Sc.—On the occurrence of snow-cover in Great Britain.

Hitherto little information has been available with regard to the frequency of snow-cover on the uplands and mountains of Great Britain. Variations with altitute are very great, variations from year to year are also very great; few highland stations are available, while their records are often brief and interrupted. Further, the interpretation, analysis and criticism of the existing data with regard to snow-lying are difficult, and are only to be undertaken after a close survey of the environment and other features of the reporting stations, of which the majority are on low ground.

A relationship has now been derived between the mean temperature of the winter months and the average frequency of occurrence of snow-lying, which after test appears to be generally applicable to any given place over a period of years. It is necessary, however, to allow for several additional factors, notably quantity of snowfall which influence the duration of snow-cover. It appears that, making these allowances, a reasonable estimate can be made of the frequency of snow-cover at the majority of places in Great Britain; also, of the extent to which the expectation of snow-cover varies with small fluctuations in mean winter temperature over a period.

The Buchan Prize of the Royal Meteorological Society for 1939 has been awarded to Mr. E. W. Hewson, M.A., Ph.D. for the following papers contributed to the *Quarterly Journal* of the Society during the years 1933–1937;

"The application of wet-bulb potential temperature to air mass analysis, I",
Ditto, II. "The ascent of air at warm fronts",
Ditto, III. "Rainfall in depressions."

Correspondence

To the Editor, *Meteorological Magazine*

The Effect of Wind on the Temperature of a Thermometer

The *Meteorological Magazine* for September, 1938 contains a discussion between Colonel Gold and myself on the reading of a thermometer placed in a high velocity air stream. I think it is worth pointing out that the views I expressed there have now received experimental confirmation in all respects save one, namely, the magnitude of the error. On this latter point no information is available.

W. F. Hilton, in the *Proceedings of the Royal Society*, **A**, **168**, pp. 43–56 (October, 1938) gives the results of an experimental investigation into this matter. Concerning the circular cylinder, he states (p. 54): " The front of a cylinder registers very nearly the adiabatic compression temperature of the air stream. . . . . The thermocouple placed at the back, however, registers within 10 per cent. of the true temperature of the moving air stream in which it is placed. Thus on a circular cylinder are to be found almost the extreme ranges of temperature possible on a body in a moving air stream. The circular cylinder is therefore a most unsatisfactory shape for the thermometry of moving fluids, since the temperature taken up by the element will be function of the conductivity of the thermometric element, and of the temperature distribution round the cylinder."

The above results are identical with these suggested by me from theoretical considerations, but they leave open the question of the mean temperature of the thermometer bulb. In view of the importance of this problem, it seems highly desirable that the magnitude of the error be investigated, either by using two aircraft, as suggested by Colonel Gold, or by mounting the thermometer on a high speed whirling arm. O. G. SUTTON.

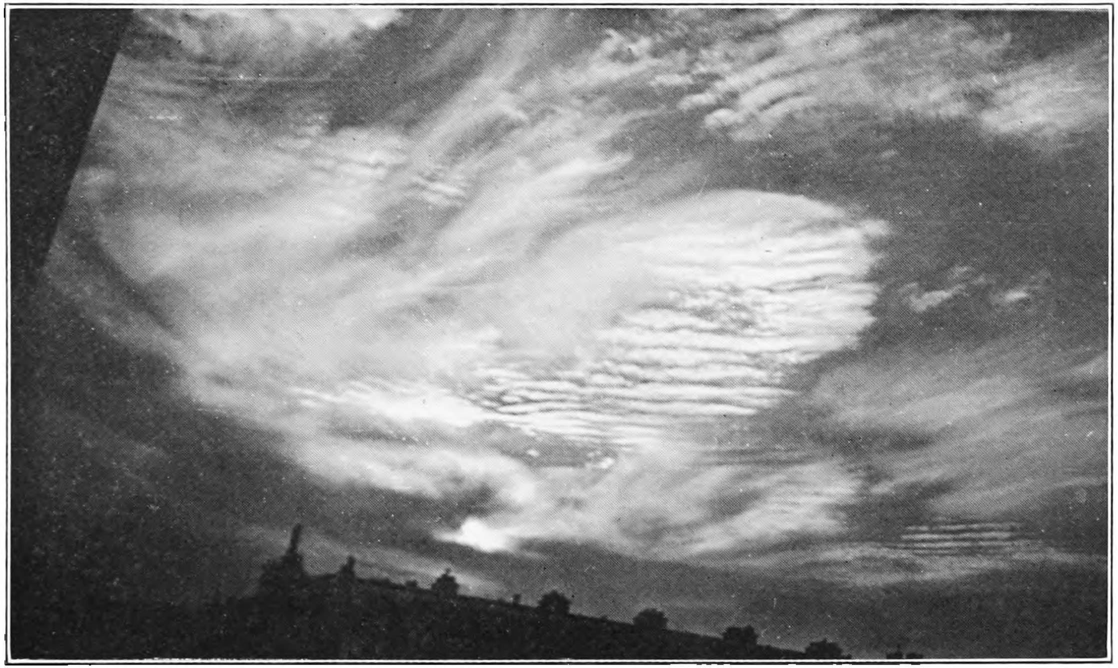
Experimental Station, Porton, Wilts, November 25th, 1938.

I am glad Mr. Sutton has drawn attention to Hilton's interesting experiments on the temperature distribution around a circular cylinder in a rapidly moving air stream. But I do not think that Hilton's results could reasonably be regarded as support for the view expressed by Mr. Sutton in his original letter that " the reading of a thermometer of conventional shape would not differ vastly from the true temperature of the air even at the speed of a modern aeroplane."

They suggest rather that the difference would be somewhere between the adiabatic effect and half that effect, i.e., between 11° F. and 5½° F. at a speed of 250 mi/hr.

Some observations with strut thermometers exposed in the manner described in my note in the *Meteorological Magazine* for September showed a difference of 3·2° F. between the readings when the aeroplane's speed was 80 mi/hr. and when it was 160 mi/hr. The

Facing page 299]



Copyright : F. E. Dixon

Cirrus Cloud below Alto-cumulus Rolls, March 11th, 1938, 17h. 5m.

(*Looking west from Meteorological Office, Edinburgh*) theoretical difference on the hypothesis of adiabatic compression is 3·5° F.

I might mention that Dr. A. A. Griffiths pointed out about 9 years ago that the circular cylinder was theoretically an unsuitable form for a thermometer bulb moving with high velocity relative to the air, if the axis of the cylinder was transverse to the airstream because of the difficulty of computing theoretically the correction to the reading necessary on account of the motion of the air.

E. GOLD.

Meteorological Office, London, W.C.2, December, 7th 1938.

Cirrus Clouds

I was much interested in the article by Mr. Mirrlees in the *Meteorological Magazine* for November, 1938. One should not too readily assume that the most typical of all cirriform features, namely the long threads, usually with vertical extension, can be produced by water drops. Snow only commences to melt when the wet bulb temperature exceeds the freezing point, and soft hail can fall for a considerable distance before it melts. Even when the illumination is such that the threads are black, the distinction between hail or snow and rain is usually quite clear.

As regards *cirrus uncinus*, the usual explanation is that of falling snow in a region of marked variation of wind with height, and this fits in with the idea of rising currents causing the showers. Whether the particles rise or fall must depend on the vertical velocity of the rising air, and on that of the particles through the air. Generally the snow flakes would fall, and the cloud heads, which consist of much smaller particles, often apparently of super-cooled droplets, would often rise. In Mr. Clarke's photograph, published as fig. 4 with Mr. Mirrlees' article, there is a typical appearance of super-cooled droplets above ice crystals. The most natural explanation of a thread is that the fall of a large particle through the air sets up small eddies and tends to drag another particle into its wake. Straight horizontal threads near the horizon may be a perspective effect.

C. K. M. DOUGLAS.

Meteorological Office, London, December 2nd, 1938.

The low "cirrus" of March 11th, 1938, described by Mr. Cruickshank,* was also seen in Edinburgh and I enclose a photograph taken from a window of the Meteorological Office. The main mass of cirrus, part of which is seen to the left of the photograph, was very dense (as is evidenced by the lack of halation round the sun) and appeared to be much lower than the alto-cumulus rolls in the centre. The clouds in the upper right hand corner resembled cirro-cumulus but showed faint iridescence.

F. E. DIXON.

Meteorological Office, Edinburgh, November 24th, 1938.

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* *Meteorological Magazine*, November, 1938, page 267.

The Prediction of Minimum Temperature on Clear Days

In a letter in the *Meteorological Magazine* for October, 1938, page 237, Mr. L. A. Ramdas refers to a formula which I gave some years ago for the total amount of long-wave radiation downward from a clear sky, and states that Raman showed "by actual computations" that my formula should be regarded as an approximation to Ångström's formula. What Raman did was to show that $b\sqrt{e}$ and $0\cdot28\ (1 - 10^{-0\cdot055e})$ can be made to agree over a wide range of values of e by a suitable choice of the constant b. We might therefore say with equal justification that what Raman did was to show "by actual computations" that Ångström's formula is an approximation to mine.

I have never seriously regarded either Ångström's formula or my own as more than an empirical formula. Now an empirical formula can only be judged on two bases, its simplicity, and the accuracy with which it represents the facts. My formula has two constants and Ångström's has three, and a square root is easier to handle than an antilogarithm. In my paper on this subject (*Q.J. Roy. Met. Soc.* **58,** 1932, p. 379), I showed that my formula gave a more accurate representation of certain observations than did Ångström's formula. So far as I can ascertain from his writings on this subject, Mr. Ramdas has made no such tests of accuracy of representation of observations with Ångström's formula, which would appear to be the normal method of deciding between two empirical formulae. The deduction of Ångström's formula on the basis of the assumption of certain mean values of the absorption coefficient within certain ranges of wave length can scarcely be regarded as conclusive. We might set against this the deduction by Pekeris and Elsasser of a formula involving the square root of the mass of absorbing material, a deduction which involves no assumption so uncertain physically as that of a mean absorption coefficient.

My investigation of the representation of observations of long-wave radiation from the atmosphere by an empirical formula showed that each series of observations requires different values of the constants in the formula. This will be true no matter which of the two formulæ in question is used, and in practice it turns out to be rather a troublesome matter to compute the values of the constants required to fit Ångström's formula to any given series of observations. D. BRUNT.

Imperial College of Science and Technology, October 31st, 1938.

The Sound of Lightning

It is possible that the swish occasionally heard with lightning is due to a brush discharge which may occur just before the flash, and may occur at various places round about, and not actually or only where the flash strikes. In a correspondence in *Nature* some years ago a ship's captain described hearing the noise, which at first he took to be a boat cover being ripped off; he heard it a number of times and each time it was before and not after the flash. It was I think Mr. J. S. Dines who suggested that whatever it is that causes the swish occurs before the flash but that most people perceive it as occurring after because a bright light may affect the brain more quickly than a not very loud sound.

A case that occurred here seems to point to the fact that the swish may originate at more than one point. Two men were working in a field when a farm was struck about 400 yards away, the men were working about 150 yards apart; each heard the swish coming apparently from nearby trees, a holly in one case, an oak in the other. The trees in both cases were in the opposite direction from the farm; one man said that when he looked up he expected to see the tree in flames.

C. J. P. CAVE.

Stoner Hill, Petersfield, October 30th, 1938.

Sunspots and Seasonal Weather

For the past fifty years I have been carefully investigating the possibility of a definite effect of sunspot periods on seasonal weather in the British Isles with the following results.

The year 1895 (*i.e.*, the winter of 1894–5) may be said to have ended a period of cold winters with one of the most severe on record; a note in *Symons's Meteorological Magazine* by me refers to frost having frozen the six-foot driving-mains of the (then) Lambeth Water Co., at a depth of some 4 ft.

After this, cold winters have recurred at alternate 12 and 10 year periods, *viz.*: 1906–7, 1916–17, 1928–9. Therefore, assuming that this sequence continues, the coming winter 1938–9 should be a severe one in January and February, as the 10 year period makes such a winter due. Colour is lent to this idea from the fact that most of our cold winters are preceded by abnormally mild Octobers and early Novembers as in this year.

In any case it will be interesting to note if the sequence holds good over the 45 years (approx.) which, I believe, is a crucial period in weather cycles.

DONALD W. HORNER.

Telford Lodge, Manor Road, Weston-super-Mare, November 8th, 1938.

Lunar Corona Observed on November 2nd, 1938

A fine lunar corona was observed at North Finchley, North London, by me at 19h. 15m. G.M.T. The aureole appeared yellowish green in colour bounded on the outside by a brownish red ring. Surrounding the aureole was another coloured ring but this appeared as a circular rainbow, red on the outside shading to yellow and green to blue and violet on the inside. At the time the sky was clear except for some cirrus clouds which stretched over the sky and across the moon.

J. MONGER.

Woodside Park, N.12, November 3rd, 1938.

Night Radiation in the Spring of 1938

From data obtained during the past two years from radiation thermometers at Goff's Oak, Herts, night radiation during the spring months (March to May) of this year seems to have been very active, compared with the corresponding period in the year 1937.

Curves showing the mean deviation of night minima of radiation thermometers, at various levels, from screen minima during the spring of the past two years are shown in Fig. 1. It will be seen that the grass minimum in spring, 1938 averages 7·8°F. below the screen minimum, against a corresponding figure of 4·2°F. in the previous year. Above five feet the differences are negligible.

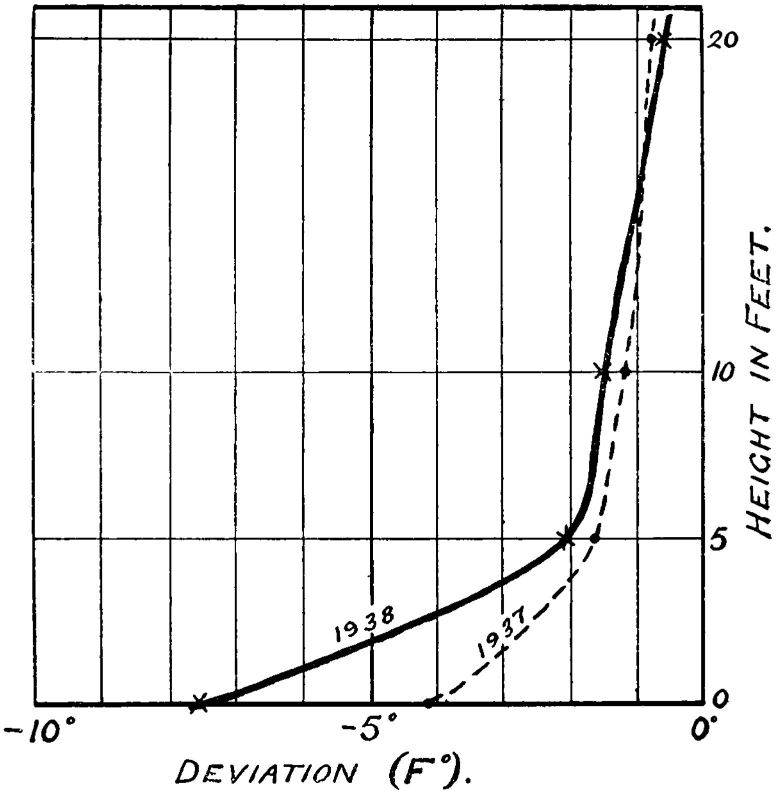

FIG. 1.

The difference between the grass minimum and that in the screen exceeded 10°F. on 30 nights in the spring of 1938, and on the night of May 9th to 10th reached the exceptional figure of 14·4°F. On the night of March 3rd to 4th the difference at five feet from the soil was as great as 4·0°F. The greatest difference at 10 ft. was 2·4°F. on the night of May 16th–17th. and on the previous night the difference at 20 ft. was 1·9°F. Differences exceeding 1·5°F. at 20 ft. were recorded on five nights. From these figures it would seem that night radiation during the past spring has been exceptionally high, and it would be of interest to know if this was general throughout the country, or peculiar to south-east Hertfordshire.

DONALD L. CHAMPION.

Meteorological Station, Goff's Oak, Herts, November 8th, 1938.

Duststorms in Iraq

In addition to the many interesting references to this type of phenomenon mentioned by Mr. Durward in the May issue of this Magazine, may I point out that such a storm furnished the background, as pointed out by Dr. W. Emery Barnes (" A New Commentary on Holy Scripture," S.P.C.K., 1928) for the " call " of the prophet Ezekiel. The relevant passage (Ezekiel I, 4) reads :—

> " And I looked, and behold, a stormy wind came out of the north, a great cloud with a fire infolding itself, and a brightness round about it, and out of the midst thereof as the colour of amber, out of the midst of the fire."

Commenting on this passage, Dr. Barnes says, " In this narrative natural phenomena and spiritual perceptions are mixed so that they can hardly be separated." (Here he quotes Col. Chesney's account, given by Mr. Durward) " Such a storm in its suddenness, its sombre glory and its sudden cessation might well suggest to the prophet the intervention of an enraged and angry Deity."

This must be the earliest reference to such a storm extant for the call of Ezekiel came in 593 B.C. CICELY M. BOTLEY.

Guildables, 17, Holmesdale Gardens, Hastings, May 20th, 1938.

The Formation of Cloud from Rising Steam

At 7h. 10m. on August 11th, a small cumulus cloud was observed developing on the top of a column of smoke and steam rising from the chimneys and condensers of Broomgrove electricity power station which lies due west and at a distance of about 1,000 yards from my observation point. The surface wind at the time was calm. The cloud began to form a little below 2,000 feet and extended upwards to at least 3,000 feet. Although the surface wind was calm the smoke and steam was rising rapidly up to the base of the cloud due, no doubt, to the convection caused by heat from the chimneys and the relatively hot water in the condenser towers. As the cloud slowly moved away from the area it dispersed and other small patches of cloud formed, but were more in the nature of fracto-stratus. The general movement of the clouds was from south-east. There was no similar cloud at the time anywhere else, though there were developing patches of alto-cumulus at 6,000 feet moving from 155° at 11 miles per hour. Cumulus clouds did not appear until a little before 9h. when they soon assumed towering masses. Cumulo-nimbus was seen developing to north-north-east at 13h. and this moved extremely slowly from an easterly point. Similar slight cloud formations have been observed from time to time as the result of rising steam from the power station (nearly always in the early morning with calm air), but they never assumed tall and well developed cumuli as that observed on this particular day.

A. E. Moon.

39, Clive Avenue, Clive Vale, Hastings, 15th August, 1938.

NOTES AND QUERIES

The Calculation of Height with a Slide Rule

It may not be widely realized, even in meteorological circles, how easy it is to calculate the height of a pressure contour above sea level with an ordinary 10–inch slide rule.

The height Z is given by

$$Z = \frac{RT}{g} \log_e \frac{P_0}{P_z}$$

This we may write as

$$Z = K\, T_m \log_{10} \frac{P_0}{P_z}$$

where T_m is the mean temperature (°A) of the layer of atmosphere and

$K = 66 \cdot 1$ to give geodynamic height.
$= 67 \cdot 4$ to give height in metres
$= 221$ to give height in feet.

Thus, if the pressure at the top of the layer (P_z) is set on Scale C against the pressure at the bottom of the layer (P_0) on Scale D, in any units, as desired, then by turning over the slide rule log $\frac{P_0}{P_z}$ is given on the L scale.*

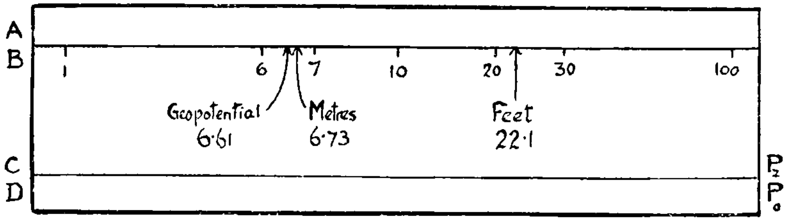

FIG. 1

This reading L is multiplied on Scale A by the mean temperature (T_m) on Scale B and then by setting figure 10 on Scale B against the product on Scale A the rule is ready to give without further adjustment—

geopotential on Scale A against 6·61 on Scale B
or height in kilometres against 6·74
or finally height in thousands of feet against 22·1.

This procedure applies strictly to an isothermal layer and with little error to a layer having a constant lapse rate: with an irregularly varying lapse rate, the atmosphere is divided into suitable layers, preferably by plotting a T log P curve.

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* On some slide-rules, a slight variation of this step is necessary.

Then $H = Z_1 + Z_2 + Z_3$ ....

$$= \Sigma K\, T_m \log \frac{P_1}{P_2}$$

Reduction of Barometer Readings.—Conversely pressure difference can be easily calculated, for if the height is known, divide it on Scale A by T_m and K consecutively on Scale B. The final dividend is $\log \frac{P_o}{P_z}$; by setting this reading on the log scale at the back of the rule, Scales C and D on the front of the rule are automatically set to read off P_z or P_o respectively in any desired units; either P_z or P_o will be known and the other read off.

R. M. POULTER.

Whirlwind at Kirton, Lincs., Nov. 18th, 1938

The following account of a whirlwind at Kirton, a village four miles south of Boston, has been received from Mr. N. H. Middlebrook, of Freiston Road, Boston:—

"On the night of Nov. 18th, 1938 before the occurrence of the whirlwind a very strong wind, accompanied by heavy rain, was blowing. At about 23h. 50m. a terrific roar was heard, lasting nearly five minutes. The whirlwind affected a strip about 150 yards wide and did most damage in Station Road, Kirton. One resident informed me that his house trembled and shook and that all kinds of articles, such as chicken huts, were hurtling through the air. Several windows were blown in, hundreds of slates were torn from roofs, and pieces of masonry removed. Large sheets of corrugated zinc were carried for considerable distances, one piece finishing its journey across some telephone wires. A large new building had most of its roof and many of its windows removed. A man who was driving at the time informed me that his car was twice turned completely round in the road."

Sir Thomas Hudson Beare

Sir Thomas Hudson Beare who is now 79 years of age enters this session on his 50th year as a professor. Twelve of those years were spent in London University and the other 38 in Edinburgh where he has been Regius Professor of Engineering. During that period Sir Thomas has been closely identified with some of the most important developments of the University including the planning and erecting of the great series of new science buildings on the south side of the city.

Sir Thomas has been a contributor of rainfall records to British Rainfall since 1906 and of complete climatological records from 1910 to the Scottish Meteorological Society and afterwards to the Meteorological Office. An evaporation gauge has also been maintained at the Engineering Department. For two years Sir Thomas Hudson Beare represented the University of Edinburgh on the Advisory Committee of the Meteorological Office, Edinburgh.

The Gale of November 23rd, 1938

A severe gale swept the greater part of the British Isles on November 23rd. It was associated with an intense depression moving northeast across the country, the position at 7h. being shown on the accompanying chart. The gale was specially severe in the Pembroke area, and at St. Ann's Head a gust reached 108 mi/hr. at 8h. 5m.,

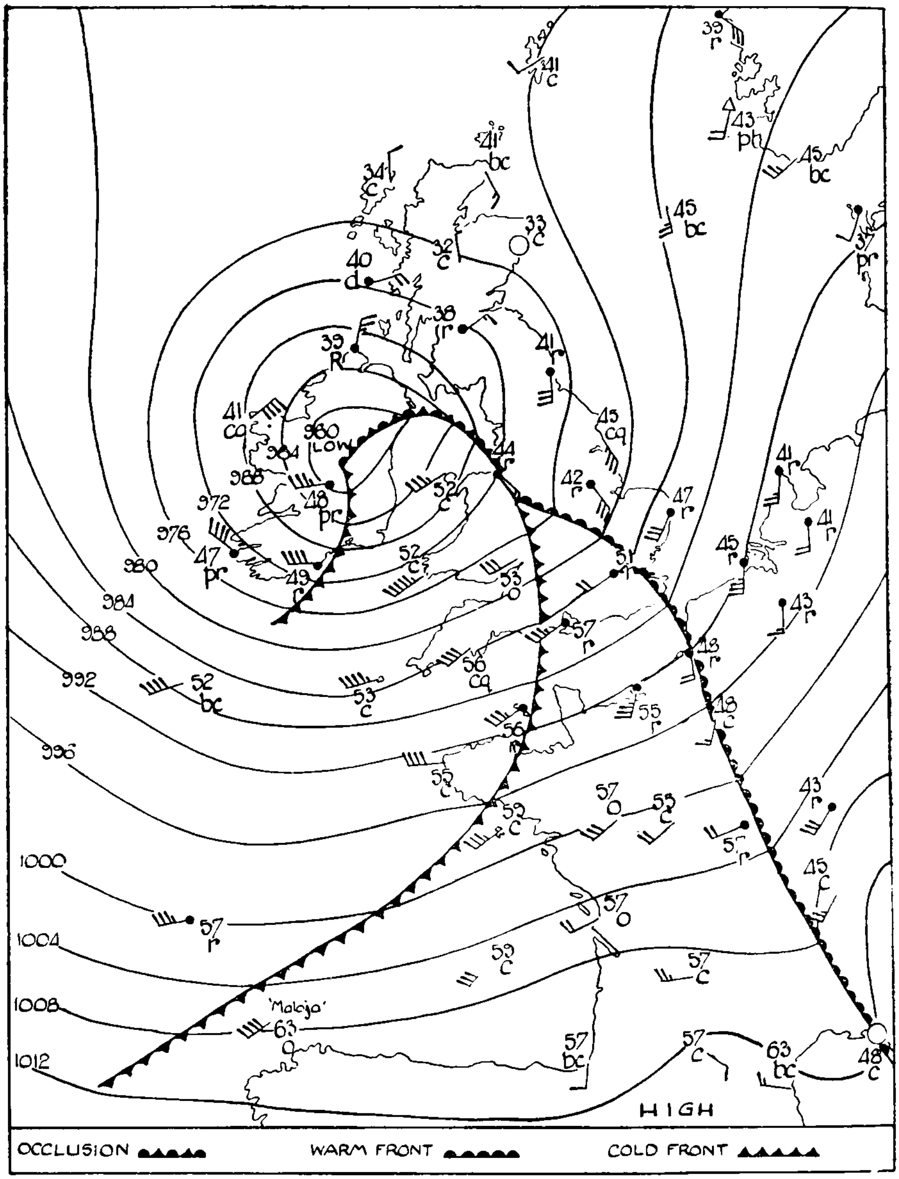
960
LOW
964
968
972
976
980
984
988
992
996
1000
1004
1008
1012
'Malcja'
HIGH
OCCLUSION
WARM FRONT
COLD FRONT

FIG. 1.—7H., NOVEMBER 23RD, 1938

closely followed by one of 107 mi/hr. at 8h. 15m. and of 106 mi/hr. at 9h. The velocity of 108 mi/hr. is among the highest yet recorded in the British Isles, but it must be kept in mind that the anemometer at St. Ann's Head has only been installed for four years, that the site is on an exposed headland with a cliff on its west side, and that the anemometer head is 70 feet above the ground.

Other notable gusts were 85 mi/hr. at Valentia at 2h. 55m., 83 mi/hr. at Birmingham at 13h. 50m. (remarkable for an inland station) and 82 mi/hr. at Lympne at 13h. 2m. As usual with severe storms, the strongest winds occurred after the first cold front had passed. There were indications of a minor cold front near Roches Point at 7h., and this would have reached Pembroke at the time of the highest gusts. The rate of travel of the depression was about 45 mi/hr., and the air on the south side was travelling much faster, averaging probably 90 mi/hr. at 2,000 feet, so that any minor fronts inevitably travelled round the trough.

Mr. C. J. Griffiths

On the retirement in November, 1938, of Mr. C. J. Griffiths, for nearly 30 years engineer to the Thames Conservancy Board, it is appropriate that we should refer in this Magazine to his interest in the study of run-off in relation to the rainfall over the Thames basin. The Thames Conservancy has published, for many years, daily values of the flow at Teddington Weir, of the amount abstracted by the Metropolitan Water Board and Water Companies and of the total estimated " natural flow ". In addition estimates are given of the general rainfall over the area day by day.

Mr. Griffiths found that it was important to know quickly the rainfall over the area, in order to estimate the height likely to be attained by the river some hours later. He made arrangements accordingly to secure rainfall records by telephone and ascertained from past information how these records were likely to represent the rainfall over the Valley as a whole. Mr. Griffith's work in using meteorological data for this purpose is likely to be of assistance to engineers of other Catchment Boards. In view of his experience Mr. Griffiths was appointed a member of the Inland Water Survey Committee set up by the Ministry of Health and Scottish Office in 1935.

Mr. Griffith's successor as engineer to the Board is Mr. R. V. W. Stock, formerly assistant engineer.

Threatening Atmosphere in Russia

While appreciating the spirit of co-operation which leads the editors of some foreign meteorological journals to publish short English summaries of papers, we may perhaps allow ourselves the luxury of a smile at the following, from a recent Russian publication :—

" In this article are discussed the turbulent qualities of the atmosphere. Is pointed out the nonuniformity of structure of the stratum of indignation by the height and is quoted its distribution on separate stratums, characterised by their structure."

The same publication also contains a paper bearing the English title :—

" About the limit of thickness of sea longevity ices."

Frequency of Ground Frosts ; Effect of the Hour of Observation

The occurrence of a " ground frost " is determined from the reading of a " grass minimum " thermometer, set in the evening and read the following morning. A ground frost is said to occur if the corrected reading is 30·4°F. or lower. At ordinary climatological stations the reading is taken at 9h. G.M.T., but at " synoptic " stations the hour of morning observation is 7h. G.M.T. Since the temperature on the grass in winter has not always fallen to its lowest value by 7h., it is clear that the recorded frequency of ground frosts will be lower at a synoptic station than at a climatological station, where the climatic conditions are identical.

At certain stations the grass minimum thermometer has been read at 7h. and again at 9h. or 10h. From these records it is possible to determine how many ground frosts are in fact " missed " by the adoption of 7h. as the hour of reading at synoptic stations. The results for the single year 1926 at four observatories (Aberdeen, Kew, Valentia and Eskdalemuir) are given in an article published in the June, 1927 issue of this Magazine. They indicate that the omissions are negligible for practical purposes. At Aberdeen the 7h. readings gave 84 frosts and the 9h. readings 86 ; at the other observatories the numbers differed by one only.

Further information has now become available, tending on the whole to confirm the view that the frequency of recorded ground frosts is not seriously diminished by observing at 7h. instead of at 9h. At Kew, during the ten years 1928 to 1937 859 ground frosts were registered at 7h. as compared with 869 at 9h., a difference of only one per cent. Of the ten ground frosts missed at 7h., three occurred in January, five in November and two in December. For other stations the number of unrecorded ground frosts was as follows : Upper Heyford (Oxfordshire) 2 in 11 years ; Sealand (Flint) 11 in 9 years ; Mount Batten (Devon), 13 in 11 years ; Cranwell (Lincs.) 4 in 5 years ; Abbotsinch (Renfrew), 5 in 5 years; Aldergrove (Antrim) 6 in 11 years. On the other hand as many as five ground frosts were missed at 7h. at Manston (Kent) during the winter of 1937 to 1938, and at Abbotsinch (Renfrew), three were missed in the single month of December, 1937. E. G. B.

REVIEWS

Methoden und Probleme der Dynamischen Meteorologie. By H. Ertel. Ergebnisse der Mathematik und ihrer Grenzgebiste. Bd. 5. No. 3. 9½ inches × 6½ inches, pp. 122. Berlin. 1938.

In so far as the reviewer is competent to judge, this monograph will take its place as a valuable work of reference for the mathematical meteorologist. It is not altogether easy to decide in what category to place the treatment; it is certainly not intended as a formal textbook for the author has selected his field to his own taste with no claim to completeness. A substantial part of the work is merely a condensed presentation of papers by numerous writers. Unfortunately mathematics does not readily permit of brevity without omission of the assumptions and approximations, the discussion of which is usually the core of the matter. This is particularly well illustrated in the last section, where the mathematical bases of ideas due to Scherhag, to Brunt and Douglas, to Stüve and Mügge, and to Ertel himself are all indicated without affording the reader any material upon which to judge their relative merits or with which to resolve their inconsistencies. There are 310 numbered equations, but the casual reader should be warned not to quote any one as carrying Ertel's certificate of validity without a careful reading of the context. No less than 246 references to the literature appear as footnotes to the text; the publication will therefore be of greatest value to the research student as a survey of the present position. The bibliography is such a vital part of the work that one regrets the omission of at least an index of authors.

How far mathematical analysis will lead to a solution of the outstanding problems of meteorology remains to be seen; real progress so far has been due more to the inspiration of the physicist and the synoptic meteorologist than to the abstruse labours of the mathematician. Indeed, if one excepts a few restricted problems it is not easy to point to any remarkable achievement involving more than a very moderate standard of mathematical analysis.

It has been said on good authority that it is possible to prove almost any absurdity in meteorology by mathematical argument, and the reviewer imagines he could illustrate this thesis from Ertel's paper. But, in spite of this, the non-mathematical meteorologist is as great a danger in the land as the non-meteorological mathematician. The physics of meteorology is with few exceptions within the grasp of anyone with a scientific education, but there are many pitfalls for the unwary; it is the dynamics which is difficult, and many of our popular conceptions will not stand the acid test of expression in mathematical form. It may be hoped that the new recruits to the science possessing the necessary mathematical equipment will not fail to apply themselves critically to the outstanding problems. Ertel's survey should prove a stimulating introduction.

R. C. SUTCLIFFE.

Meteorology as a Career. The Institute of Research, Chicago. No. 84. 11 inches × 8½ inches, pp. 20. *Illus.* Chicago. 1938.

This is an interesting and well printed pamphlet published for the purpose of informing young people and their parents in the United States of the prospects of meteorology as a profession. Full details are given not only of the duties and emoluments of the various grades of employment, but also of the high school and college training necessary before the candidate can hope to begin his career. The unattractive as well as the attractive features of meteorological work are frankly set forth, and the anonymous author is obviously well informed. All will agree with the following, under the heading "Personal Qualifications Necessary":—

> "To scientific ability must be added a passion for the truth and the willingness to exert painstaking effort in verifying the accuracy of observations and researches in his field";

and also with the following:—

> "A forecaster is subjected to continuous 'kidding' from other persons about his forecasts and possible mistakes. A worrying type of person will soon succumb to the continuous psychological stress of whether or not a forecast will turn out right."

From the details given in the pamphlet one forms the impression that meteorology is being handled in the United States in a characteristically "go-ahead" manner, to meet the rapidly growing needs of aviation, forestry and other services.

E. G. B.

BOOKS RECEIVED

The law of storms in the China Sea. By C. W. Jeffries and G. S. P. Heywood. Royal Observatory, Hong Kong, 1938.

Some comparisons of the invigorating effect of the climate in different parts of New Zealand. By W. A. Macky (No. 18).

Visibility and upper winds at Auckland, Wellington and Christchurch. By L. N. Laisen (No. 20).

Climatological observations at Eastbourne, Wellington, and some comparisons. By W. A. Macky (No. 21). New Zealand; Dept. of Sc. and Ind. Res. Met. Office Notes, Wellington, 1937–1938.

The Weather of November, 1938

The northern North Atlantic was occupied by an intense area of low pressure, centred over Iceland where the mean of 990 mb. was 12 mb. below normal. Pressure was normal (1021 mb.) over the Azores, and 5 mb. above normal at Bermuda and in the Mediterranean, so that the south–north pressure gradient over the Atlantic and western Europe was abnormally steep. The prevailing strong westerly winds made the north very mild over the whole of western and central Europe. The mean temperatures were 35° F. to 40° F. in Scandinavia, 45° F.–52° F. in the British Isles, about 45° F. in central and south-eastern Europe and 55° F. to 63° F. in the Mediterranean, the difference from normal ranging from zero in Scotland to + 5° F. in England, France and Germany and Scandinavia and 10° F. in Finland. In Canada pressure and temperature differed little from normal except in the far north-west, where low pressure over the Arctic Ocean gave temperatures a few degrees above normal. Rainfall was abnormally heavy on the western coasts of Europe, but farther east it was below normal in most places.

The weather of the month in the British Isles was exceptionally mild; at Wakefield and Ross-on-Wye it was the mildest November on record, while at Oxford, in a record which goes back to 1815, the mean temperature, 49·3° F., was the highest for November since 1818. At a number of stations the maximum temperature on the 5th was the highest on record in November. Winds from between south and west predominated and the month was wet on the whole; at Eskdalemuir and Renfrew the total rainfall was the highest recorded in November since readings were first taken in 1910 and 1921 respectively. The duration of sunshine was very variable; for example, at Chester (Sealand) it was the sunniest November on record and at Eskdalemuir it was the dullest. A widespread and unusually severe gale occurred on the 23rd; the wind speed in a gust rose to 108 m.p.h. at St. Ann's Head Pembroke.

On the 1st and 2nd a deep depression off the north of Scotland moved north-north-east while an associated trough of low pressure moved eastward over the British Isles; gales occurred in the west and north on the 1st and 2nd, and moderately heavy rain in northern districts on the 1st. Local thunderstorms were reported in Scotland and northern England and snow locally in Scotland. On the 3rd and 4th Atlantic depressions moved north-east and heavy rain fell at a number of places in the west and north on the 3rd. Between the 5th and 15th an anticyclone moved north-east from Spain to central Europe and then eastward to Russia; meanwhile Atlantic depressions moved north-east or north along our western seaboard. This pressure distribution caused a flow of unusually mild equatorial air over the British Isles; from the 1st–19th widely separated stations had a mean temperature more than ten degrees Fahrenheit above their respective averages for November, while Tottenham had a positive deviation of 14·3° F. and Sealand 14·2° F. Heavy rain fell at times in the west and north; on the 12th, for example, 3·54 in. was registered at Troutbeck, Cumberland, 3·50 in. at Borrowdale, Cumberland, and 2·50 in. at Ballynahinch Castle, County Galway. A deep depression situated to the north of Scotland caused gales in the north and west and considerable rain generally on the 18th and 19th; a gust of 98 m.p.h. was registered at Stornoway, in the northern Hebrides, on the 18th.

Subsequently, from the 20th onwards, depressions moved more directly over the British Isles; lower temperatures prevailed and rain fell frequently. On the 23rd an intense depression moved rapidly north-east from Ireland to southern Norway causing widespread and severe gales over the British Isles. Cool northerly winds prevailed in the rear of this depression. Wintry precipitation occurred locally at times in the north between the 19th and 28th, snow being reported to be lying to a depth of 4 in. on high ground in southern Scotland on the 23rd. Local thunderstorms were reported between the 17th and 20th, and 23rd and 30th. Secondary depressions moving north-east over the country caused heavy rain, particularly in southern districts during the 24 hours ending at 9 a.m. on the 26th; 2·91 in. fell at Totnes, 2·35 in. at Holne, Devon, and 2·26 in. at Ipplepen Vicarage, Devon.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway	30	−16	Chester	89	+36
Aberdeen	74	+15	Ross-on-Wye	73	+10
Dublin	83	+12	Falmouth	53	−23
Birr Castle	56	− 5	Gorleston	62	− 4
Valentia	36	−27	Kew	62	+ 9

Kew temperature, mean, 49·7°F.: diff. from average, +5·4°F.

Miscellaneous Notes on Weather Abroad

As a result of warm weather many Alpine passes were reopened to traffic early in the month, and ascents of the Matterhorn and the Kempfisch Horn, near Zermatt, were made—a feat hitherto regarded as impossible. Great damage was done by gales on the south-west coast of France, and heavy rainstorms caused floods in northern Italy on the 22nd. A severe storm was encountered in the Bay of Bengal by the long-distance flight aeroplanes on the 8th, the airscrew being surrounded by St. Elmo's fire at the height of the storm. During a thunderstorm at Aziz, near Aleppo, on the 9th, eight persons were reported killed and 60 houses damaged. Floods were experienced in Batavia on the 29th; many landslips and much damage resulted and 65 natives lost their lives. The first snowstorm of the season was reported from Newfoundland on the 4th and from many parts of the United States on the 7th, while in New York State and Maryland, shade maxima of 76° F. were recorded. A cold wave followed and at Syracuse on the 24th, 19° of frost were reported. Snow and fog accompanied the low temperatures resulting in a death roll from accidents of over 50. Fourteen inches of snow fell in New York City from the 24th–27th. Heavy rains during the month are thought to be a partial cause of the mountain split in St. Lucia on the 21st. A further landslip which buried many of the injured and the rescuers brought the total loss of life to 75. Gales, reaching 90 miles per hour at times, caused damage to shipping around Nova Scotia on the 27th : the storm was followed by unusual warmth. An aeroplane was blown out to sea and smashed on rocks near San Francisco during a gale on the 27th. Drought conditions are reported from Victoria. Many wheat crops have failed entirely, and all are very bad.

The Times, November 4th–30th, 1938.

Daily Readings at Kew Observatory, November, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain	Sun	REMARKS
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	1004·3	W. 4	49	56	47	0·10	4·9	r–r_0 4h.–7h. & 8h -9h.
2	1007·3	WSW. 4	42	54	61	trace	5·6	pr_0 14h.
3	1015·4	SW. 2	47	55	69	—	0·1	
4	1014·8	SW. 3	52	61	81	trace	0·1	pr_0 1h. & 15h.
5	1023·5	WSW. 3	57	66	77	—	7·3	
6	1024·4	SW. 3	55	57	90	trace	0·0	id_0 8h.–12h. & 21h.
7	1018·4	SW 2	53	56	89	trace	0·0	id_0 8h.–13h. & 17h.
8	1017·1	SW. 2	49	55	75	trace	0·0	d_0 12h., f 23h.–24h.
9	1017·7	SE. 3	43	51	80	—	0·0	f 0h.–1h.
10	1015·2	SE. 2	49	58	78	—	4·3	
11	1006·5	SE. 3	48	62	68	0·08	4·8	r–r_0 15h.–17h.
12	1012·4	S. 5	52	61	82	0·09	1·0	ir_0–r 7h.–12h.
13	1013·6	S. 4	57	61	84	0·04	0·0	ir_0–r 12h.–22h.
14	1024·8	SW. 2	55	59	73	0·01	2·0	pr_0 3h.
15	1030·4	SSW. 1	47	50	96	trace	0·0	f 6h.–19h., $d_0$9h. & 21h.
16	1022·9	E. 2	47	55	93	0·04	0·0	r_0–r7h.–9h.&13h.–15h.
17	1023·3	SW. 2	52	54	78	0·01	0·1	r_0 2h.–3h., d_0 21h.
18	1019·9	S. 3	50	56	77	0·04	0·6	f 0h.–8h., r_0 21h.–23h.
19	1014·3	SW. 3	45	50	68	0·18	3·9	r–r_0 0h.–4h., pr_0 19h.
20	997·9	SSE. 4	43	51	87	0·61	0·0	r–r_0 3h.–7h.&11h.–18h.
21	989·7	N. 2	37	43	94	0·01	0·0	f–F 8h.–24h., r_0 23h.
22	997·4	W. 3	39	47	66	trace	6·2	r_0 0h.–1h.
23	981·7	SW. 7	40	56	55	0·12	3·1	r–r_0 2h.–7h., pr_0 15h.
24	1004·8	W. 3	37	47	64	—	3·7	
25	1005·8	SW. 4	36	52	73	0·57	0·8	r_0 5h., r–r_0 19h.–23h.
26	1002·2	WSW. 3	46	48	68	0·33	5·2	r 0h.–4h.
27	1013·9	S. 3	32	47	69	0·01	4·6	f 9h., ir_0 16h.–17h.
28	1002·4	SSW. 2	47	49	96	0·26	0·0	r–r_0 0h.–5h., pr_0 16h.
29	1010·2	SW. 1	32	44	83	—	0·6	f 8h.–23h.
30	994·9	WSW. 4	34	52	67	0·10	3·0	r_0 5h.–7h. & 9h.–10h.
*	1010·9	—	46	54	76	2·60	2·1	*Means or Totals.

General Rainfall for November, 1938

England and Wales	141	per cent of the average 1881–1915.
Scotland	157	
Ireland	156	
British Isles ...	147	

Rainfall : November, 1938 : England and Wales

Co.	Station.	In.	Per cent of Av.	Co.	Station.	In.	Per cent of Av.
Lond .	Camden Square..........	2·98	126	*War* ·	Birminghm. Edgbaston	3·40	143
Sur .	Reigate, Wray Pk. Rd..	4·29	137	*Leics* .	Thornton Reservoir ...	2·52	111
Kent .	Tenterden, Ashenden...	3·38	112	,, .	Belvoir Castle............	2·33	104
,, .	Folkestone, I. Hospital.	3·21	...	*Rut* .	Ridlington	2·51	109
,, .	Margate, Cliftonville....	1·89	78	*Lincs* .	Boston, Skirbeck.........	1·83	92
,, .	Eden'bdg., Falconhurst	4·13	116	,, .	Cranwell Aerodrome...	1·83	98
Sus .	Compton, Compton Ho.	5·28	139	,, .	Skegness, Marine Gdns.	2·17	100
,, .	Patching Farm..........	4·13	116	,, .	Louth, Westgate.........	2·65	103
,, .	Eastbourne, Wil. Sq....	4·85	139	,, .	Brigg, Wrawby St.......	2·08	...
Hants.	Ventnor, Roy.Nat.Hos.	4·81	150	*Notts* .	Mansfield. Carr Bank...	3·48	143
,, .	Southampton,East Park	5·31	169	*Derby*.	Derby, The Arboretum	2·60	115
,, .	Ovington Rectory.......	5·57	168	,, .	Buxton, Terrace Slopes	6·44	138
,, .	Sherborne St. John......	5·11	179	*Ches* .	Bidston Obsy.............	3·18	127
Herts .	Royston,Therfield Rec.	2·69	115	*Lancs*.	Manchester, Whit. Pk.	4·10	155
Bucks.	Slough, Upton............	3·09	139	,, .	Stonyhurst College......	5 97	132
Oxf .	Oxford, Radcliffe.........	3·16	137	,, .	Southport, Bedford Pk.	4·86	155
N'hant	Wellingboro, Swanspool	2·39	111	,, .	Ulverston, Poaka Beck	7·55	136
,, .	Oundle	1·68	...	,, .	Lancaster, Greg Obsy.	6·05	152
Beds .	Woburn, Exptl. Farm...	2·34	104	,, .	Blackpool	5·04	145
Cam .	Cambridge, Bot. Gdns.	1·90	98	*Yorks*.	Wath-upon-Dearne......	2·40	113
,, .	March......................	1·98	97	,, .	Wakefield,Clarence Pk.	3·06	144
Essex.	Chelmsford,County Gdns	2·95	131	,, .	Oughtershaw Hall.......	10·54	...
,, .	Lexden Hill House......	2·31	...	,, .	Wetherby, Ribston H..	3·47	148
Suff .	Haughley House.........	2·02	...	,, .	Hull, Pearson Park......	2·28	104
,, .	Rendlesham Hall........	2·47	111	,, .	Holme-on-Spalding......	2·82	129
,, .	Lowestoft Sec. School...	2·48	106	,, .	Felixkirk, Mt. St. John.	3·19	130
,, .	Bury St. Ed., WestleyH.	2·85	124	,, .	York, Museum...........	2·55	122
Norf. .	Wells, Holkham Hall...	1·95	91	,, .	Pickering, Houndgate...	3·15	127
Wilts .	Porton, W.D. Exp'l. Stn	4·60	176	,, .	Scarborough..............	2·81	114
,, .	Bishops Cannings........	3·54	124	,, .	Middlesbrough...........	2·32	109
Dor .	Weymouth, Westham.	5·21	168	,, .	Baldersdale, Hury Res.	5·64	152
,, .	Beaminster, East St....	7·13	180	*Durh* .	Ushaw College...........	2·64	104
,, .	Shaftesbury...............	3·94	122	*Nor* .	Newcastle, Leazes Pk...	2·71	115
Devon.	Plymouth, The Hoe....	8·36	229	,, .	Bellingham, Highgreen	4·81	140
,, .	Holne, Church Pk. Cott.	13·40	208	,, .	Lilburn Tower Gdns....	3·47	104
,, .	Teignmouth, Den Gdns.	6·17	193	*Cumb*.	Carlisle, Scaleby Hall...	6·75	225
,, .	Cullompton	6·38	185	,, .	Borrowdale, Seathwaite	20·50	160
,, .	Sidmouth, U.D.C........	4·80	...	,, .	Thirlmere, Dale Head H.	16·41	169
,, .	Barnstaple, N. Dev.Ath	6·32	161	,, .	Keswick, High Hill......	11·33	200
,, .	Dartm'r,Cranmere Pool	12·00	...	,, .	Ravenglass, The Grove	8·14	182
,, .	Okehampton, Uplands.	9·82	185	*West* .	Appleby, Castle Bank...	5·28	159
Corn .	Redruth, Trewirgie......	7·68	158	*Mon* .	Abergavenny, Larchf'd	5·64	148
,, .	Penzance, Morrab Gdns.	7·96	174	*Glam* .	Ystalyfera, Wern Ho....	11·21	171
,, .	St. Austell, Trevarna...	8·39	170	,, .	Treherbert, Tynywaun.	16·15	...
Soms .	Chewton Mendip.........	7·11	166	,, .	Cardiff, Penylan..........	6·24	154
,, .	Long Ashton............	5·18	163	*Carm* .	Carmarthen,M. & P. Sch.	11·77	229
,, .	Street, Millfield..........	3·58	132	*Card* .	Aberystwyth	5·81	...
Glos .	Blockley	3·18	...	*Rad* .	BirmW.W.Tyrmynydd	10·58	159
,, .	Cirencester, Gwynfa....	3·83	129	*Mont* .	Lake Vyrnwy	10·27	185
Here .	Ross-on-Wye.............	3·21	127	*Flint* .	Sealand Aerodrome......	3·24	138
,, ·	Kington, Lynhales.......	4·75	148	*Mer* .	Blaenau Festiniog	10·41	107
Salop.	Church Stretton.........	5·64	192	,, .	Dolgelley, Bontddu......	7·63	123
,, .	Shifnal, Hatton Grange	3·35	139	*Carn* ·	Llandudno	2·81	97
,, .	Cheswardine Hall........	3·82	147	,, .	Snowdon, L. Llydaw 9..	22·95	...
Worc .	Malvern, Free Library...	3·01	119	*Ang* .	Holyhead, Salt Island...	5·96	144
,, .	Ombersley, Holt Lock.	2·88	126	,, .	Lligwy	7·52	...
War .	Alcester, Ragley Hall...	2·38	103	*I. Man*	Douglas, Boro' Cem....	5·31	113

Rainfall : November, 1938 : Scotland and Ireland

Co.	Station.	In.	Per cent of Av.
Guern.	St.Peter P't.Grange Rd.	5·36	128
Wig .	Pt. William, Monreith.	6·73	156
,, .	New Luce School	6·76	132
Kirk .	Dalry, Glendarroch	10·60	177
Dumf.	Eskdalemuir Obs	11·68	201
Roxb .	Hawick, Wolfelee	7·65	198
,, .	Kelso, Broomlands	3·47	150
Peeb .	Stobo Castle	7·98	241
Berw .	Marchmont House	4·23	141
E.Lot .	North Berwick Res	...	...
Midl .	Edinburgh, Blackfd. H.	4·46	199
Lan .	Auchtyfardle	8·28	...
Ayr .	Kilmarnock, Kay Park	6·10	...
,, .	Girvan, Pinmore	7·82	147
,, .	Glen Afton, Ayr San.	10·86	197
Renf .	Glasgow, Queen's Park	7·93	213
,, .	Greenock, Prospect H.	12·37	204
Bute .	Rothesay, Ardencraig	10·31	203
,, .	Dougarie Lodge	7·86	150
Arg .	Loch Sunart, G'dale	12·09	162
,, .	Ardgour House	18·93	...
,, .	Glen Etive	21·12	204
,, .	Oban	13·74	...
,, .	Poltalloch	11·82	210
,, .	Inveraray Castle	21·43	254
,, .	Islay, Eallabus	9·27	172
,, .	Mull, Benmore	22·30	155
,, .	Tiree	7·46	154
Kinr .	Loch Leven Sluice	4·94	138
Fife .	Leuchars Aerodrome	3·39	148
Perth .	Loch Dhu	15·65	180
,, .	Crieff, Strathearn Hyd.	7·79	179
,, .	Blair Castle Gardens	7·52	214
Angus.	Kettins School	4·02	130
,, .	Pearsie House	4·62	...
,, .	Montrose, Sunnyside	3·68	139
Aber .	Balmoral Castle Gdns.	4·46	121
,, .	Logie Coldstone Sch.	2·86	93
,, .	Aberdeen Observatory.	2·68	91
,, .	New Deer School House	2·62	78
Moray	Gordon Castle	2·31	80
,, .	Grantown-on-Spey	3·64	122
Nairn.	Nairn	3·06	130
Inv's .	Ben Alder Lodge	10·24	...
,, .	Kingussie, The Birches.	5·38	...
,, .	Loch Ness, Foyers	7·98	205
,, .	Inverness, Culduthel R.	4·66	183
,, .	Loch Quoich, Loan	32·04	...
,, .	Glenquoich	24·26	200
,, .	Arisaig House	9·96	148
,, .	Glenleven, Corrour	17·48	233
,, .	Fort William, Glasdrum	17·55	...
,, .	Skye, Dunvegan	12·99	...
,, .	Barra, Skallary	8·50	...
R&C	Tain, Ardlarach	3·65	113
,, .	Ullapool	7·99	150
,, .	Achnashellach	14·63	160
R&C .	Stornoway, C.GuardStn.	5·72	103
Suth .	Lairg	3·65	91
,, .	Skerray Borgie	6·41	...
,, .	Melvich	4·54	113
,, .	Loch More, Achfary	12·61	147
Caith .	Wick	2·80	89
Ork .	Deerness	4·39	112
Shet .	Lerwick Observatory	6·20	146
Cork .	Cork, University Coll.	5·95	148
,, .	Roches Point, C.G. Stn.	5·78	138
,, .	Mallow, Longueville	5·67	152
Kerry.	Valentia Observatory	7·26	133
,, .	Gearhameen	12·80	132
,, .	Bally McElligott Rec.	5·57	...
,, .	Darrynane Abbey	6·14	120
Wat .	Waterford, Gortmore	6·31	171
Tip .	Nenagh, Castle Lough.	6·15	153
,, .	Cashel, Ballinamona	5·20	150
Lim .	Foynes, Coolnanes	5·70	140
,, .	Limerick, Mulgrave St.	5·55	144
Clare .	Inagh, Mount Callan	9·92	...
Wexf .	Gorey, Courtown Ho.	6·40	183
Wick .	Rathnew, Clonmannon.	6·09	...
Carl .	Bagnalstown, Fenagh H.	5·22	156
,, .	Hacketstown Rectory	5·79	149
Leix .	Blandsfort House	5·96	178
Offaly.	Birr Castle	4·68	151
Kild .	Straffan House	2·45	78
Dublin	Dublin, Phoenix Park.	2·54	90
Meath.	Kells, Headfort	4·58	135
W.M .	Moate, Coolatore	4·65	...
,, .	Mullingar, Belvedere	5·16	151
Long .	Castle Forbes Gdns	5·95	165
Gal .	Galway, Grammar Sch.	6·36	156
,, .	Ballynahinch Castle	17·10	286
,, .	Ahascragh, Clonbrock.	6·18	153
Rosc .	Strokestown, C'node	6·52	192
Mayo.	Blacksod Point	10·60	203
,, .	Mallaranny	11·82	...
,, .	Westport House	9·63	197
,, .	Delphi Lodge	19·19	184
Sligo .	Markree Castle	6·85	165
Cavan.	Crossdoney, Kevit Cas.	5·64	...
Ferm .	Crom Castle	6·26	180
Arm .	Armagh Obsy	4·06	143
Down.	Fofanny Reservoir	11.07	...
,, .	Seaforde	5.22	138
,, .	Donaghadee, C. G. Stn.	3.59	118
Antr .	Belfast, Queen's Univ.	4.55	135
,, .	Aldergrove Aerodrome.	4.06	125
,, .	Ballymena, Harryville.	5.82	144
Lon .	Garvagh, Moneydig	6.40	...
,, .	Londonderry, Creggan.	7.47	182
Tyr .	Omagh, Edenfel	7.52	198
Don .	Malin Head	6.35	156
,, .	Dunfanaghy	7.40	179
,,	Dunkineely	8·45	...

Climatological Table for the British Empire, June, 1938

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean							
	Mean of Day M.S.L.	Diff. from Normal.	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.			Am'nt.	Diff. from Normal.	Days	Hours per day.	Percentage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy.	1017·2	+ 0·5	77	45	69·6	53·1	61·3	+ 2·3	53·5	72	7·3	0·35	− 1·80	7	6·9	42
Gibraltar	1017·1	− 0·2	88	60	76·2	64·2	70·2	− 0·3	63·5	80	3·7	0·04	...	2	...	...
Malta	1017·9	+ 2·7	87	61	79·6	66·6	73·1	+ 0·4	66·1	71	1·5	0·00	− 0·09	0	12·6	87
St. Helena	1019·3	− 0·7	70	54	64·7	57·2	60·9	+ 1·1	58·7	92	8·6	2·06	− 0·76	21	...	...
Freetown, Sierra Leone	1013·4	+ 3·1	87	68	84·7	73·0	78·9	...	75·3	83	7·3	13·33	− 6·71	24	...	...
Lagos, Nigeria	1013·2	+ 0·8	88	71	84·0	74·1	79·1	− 0·4	74·9	90	7·5	11·52	− 6·96	15	4·3	35
Kaduna, Nigeria	1011·8	...	93	66	89·2	68·9	79·1	+ 2·4	71·1	83	7·9	5·26	− 1·83	13	7·9	62
Zomba, Nyasaland	1019·1	+ 1·4	81	51	71·7	55·0	63·3	+ 0·4	59·8	80	6·2	0·56	+ 0·08	8	...	...
Salisbury, Rhodesia	1021·6	+ 0·2	77	39	68·2	44·7	56·5	− 0·4	49·5	60	3·7	0·12	...	1	6·9	62
Cape Town	1022·3	+ 2·2	86	35	69·1	49·3	59·2	+ 3·5	50·3	88	4·4	1·97	− 2·53	10	...	...
Johannesburg	1023·4	+ 1·6	66	33	60·6	43·3	51·9	+ 1·2	43·1	60	0·3	0·21	+ 0·07	2	8·1	77
Mauritius	1019·6	+ 0·8	78	57	75·4	63·3	69·3	− 0·1	65·5	72	3·8	0·85	− 1·56	12	8·6	79
Calcutta, Alipore Obsy.	999·5	− 0·2	96	77	90·0	79·8	84·9	− 0·2	80·5	85	8·6	9·15	− 2·76	13*	...	...
Bombay	1002·7	− 1·3	90	73	85·7	77·4	81·5	− 2·5	78·0	86	9·0	31·24	+ 11·37	26*	...	...
Madras	1003·4	− 0·4	100	74	95·6	79·6	87·6	− 2·4	75·0	62	8·4	1·85	− 0·12	6*	...	...
Colombo, Ceylon	1009·0	+ 0·4	87	73	86·1	78·7	82·4	+ 0·8	77·2	75	7·9	1·94	− 5·38	17	5·5	44
Singapore	1009·5	+ 0·6	89	71	87·3	77·5	82·4	+ 0·9	78·2	76	6·1	6·05	− 0·82	8	8·3	68
Hongkong	1007·1	+ 1·3	94	77	89·0	80·2	84·6	+ 3·2	79·3	76	5·8	2·99	− 12·71	11	8·7	65
Sandakan	1008·8	...	89	71	86·5	75·0	80·7	− 1·0	76·7	85	7·9	11·05	+ 3·55	16	...	...
Sydney, N.S.W.	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Melbourne	1019·0	+ 0·5	63	33	56·5	43·9	50·2	− 0·2	45·4	80	6·6	4·02	+ 1·96	20	2·6	27
Adelaide	1020·6	+ 1·2	66	37	59·3	44·8	52·1	− 1·5	47·4	77	7·8	2·37	− 0·71	17	3·7	38
Perth, W. Australia	1023·5	+ 5·5	72	42	63·7	48·5	56·1	− 0·7	50·5	75	5·3	5·51	− 1·43	14	5·6	56
Coolgardie	1021·9	+ 3·0	74	35	58·9	42·3	50·6	− 2·2	46·7	81	4·7	1·19	− 0·07	5	...	...
Brisbane	1019·8	+ 1·5	77	41	69·0	51·6	60·3	+ 0·1	53·2	70	4·2	0·86	− 1·93	8	7·0	67
Hobart, Tasmania	1013·7	− 0·6	59	35	53·4	41·6	47·5	+ 0·5	43·3	77	5·6	4·08	+ 1·85	16	3·7	41
Wellington, N.Z.	1012·7	− 2·2	62	35	53·2	43·7	48·5	− 1·0	46·3	81	7·2	7·50	+ 2·73	18	3·2	35
Suva, Fiji	1013·3	− 0·3	86	65	80·9	70·9	75·9	+ 1·2	71·7	87	5·8	4·84	− 1·87	18	4·6	41
Apia, Samoa	1011·6	0·0	87	72	84·9	74·6	79·7	+ 1·9	75·7	79	4·8	3·74	− 1·61	17	7·9	70
Kingston, Jamaica	1014·6	+ 0·8	93	72	88·8	73·	81·2	− 0·1	72·2	75	3·8	2·29	− 1·81	4	6·8	52
Grenada, W.I.	1010·2	+ 3·1	89	71	86	73	79·5	+ 0·5	74	78	6	15·36	+ 7·11	22	...	...
Toronto	1015·4	+ 0·7	88	47	75·8	55·8	65·8	+ 2·0	58·2	72	4·9	1·49	− 1·17	13	7·7	50
Winnipeg	1014·0	+ 2·2	93	30	74·2	50·1	62·1	− 0·2	50·9	83	5·6	1·32	− 1·79	15	7·1	44
St. John, N.B.	1015·0	+ 1·5	82	45	65·8	50·3	58·1	+ 1·6	54·0	87	7·3	4·32	+ 1·05	19	6·1	39
Victoria, B.C.	1017·6	+ 0·8	77	45	65·7	49·7	57·7	+ 0·7	53·3	73	3·6	0·02	− 0·82	2	11·2	70

Frontispiece]

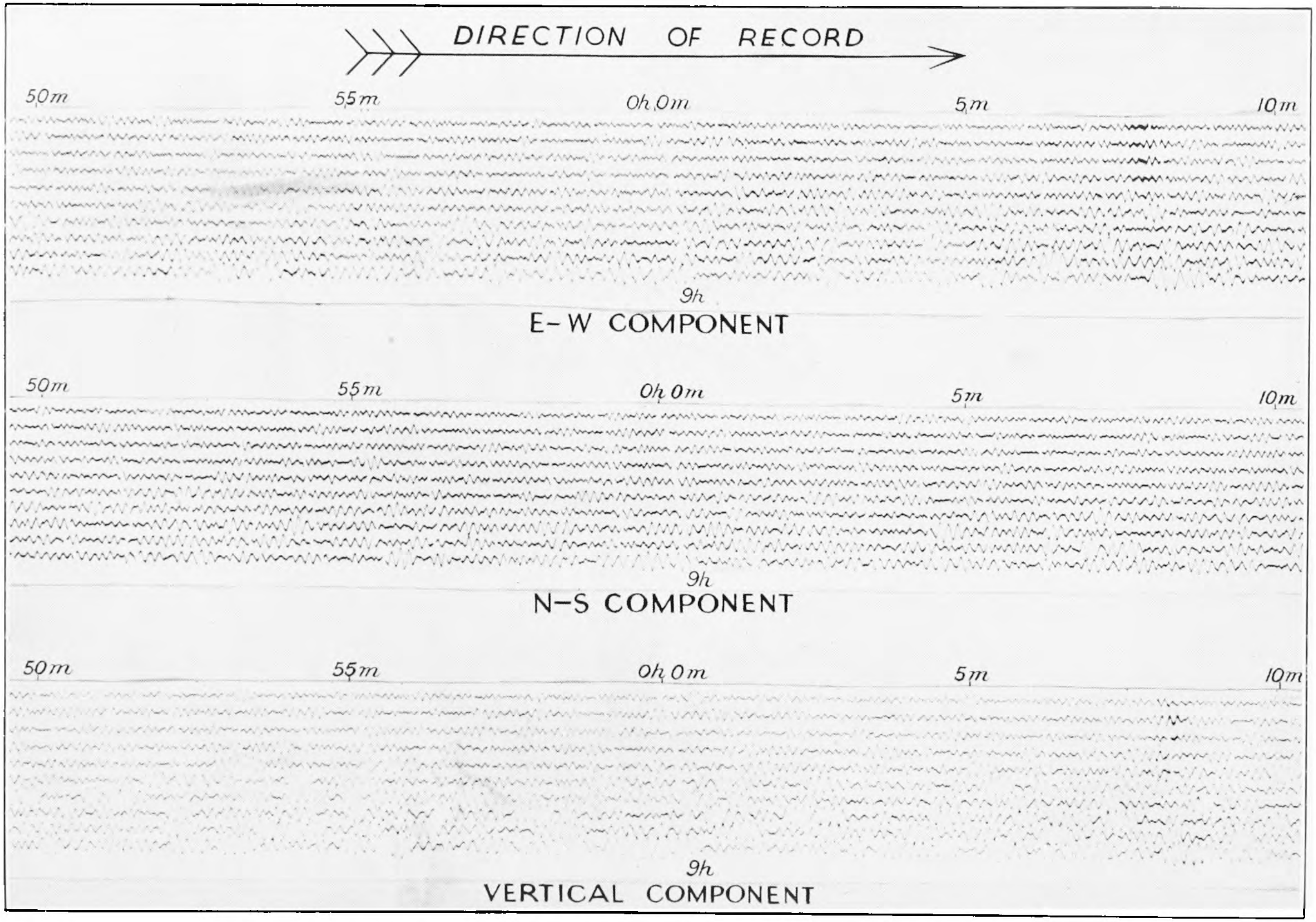

FIG. I.—MICROSEISMS RECORDED AT KEW OBSERVATORY, NOVEMBER 28TH, 1938

M.O. 422.

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MICROSEISMS AND WEATHER

By A. W. Lee, D.Sc.

Microseisms are the minute oscillations of the ground so aptly represented by the German designation *Bodenunruhe*, literally ground unrest. Long before seismographs were invented it had been noticed that in certain delicate experiments the instruments were disturbed owing to persistent movements of the ground. Early in the nineteenth century Kater found that determinations of gravity from pendulum observations in London were affected by these vibrations. Mention may also be made of the attempts of G. and H. Darwin to measure the effect of lunar attraction upon gravity; the experiments were carried out at Cambridge from 1880 to 1882, but had to be abandoned owing to the incessant vibration of the ground. More recently, since seismographs have been brought into use for detecting the tremors from earthquakes and continuous records of the earth movements have been obtained, much has been learned about the nature of the microseisms and the causes which produce them. It has been found that the effects of traffic or machinery in the vicinity are generally shown in the seismograms as a series of very rapid oscillations of periods not more than a second or two; at some observatories rather irregular oscillations with periods greater than about 10 seconds can be attributed to local strong winds and possibly also to frost. The most regular and most widely observed movements, however, are those with periods 3 to 10 seconds. These movements, which are nearly always visible in the records of sensitive seismographs, are larger in winter than in summer. It has been established that they are generated from storms and are not related to local causes. Throughout the remainder of this article the term microseisms is restricted to these movements, sometimes referred to as " ordinary " microseisms.

Fig. 1 shows typical records of microseisms obtained from the Galitzin seismographs at Kew Observatory. Three components of the earth movement are recorded—the vertical, and the horizontal in the directions north–south and east–west; the time interval between the successive breaks in the records is exactly a minute. These records were obtained during the early hours of 28th November, 1938, when there was a progressive change in the microseisms, the amplitudes* increasing from about 3μ at 0h. to about 10μ at 9h. and the period lengthening from near 6 sec. to over 9 sec.

Microseisms occur in all parts of the world. The amplitudes and periods of the waves recorded at any observatory are continually changing, and there are occasions when the movements are exceptionally large ; during these " microseismic storms " the disturbances are widespread, vibrations of nearly the same period being recorded, for instance, throughout the whole of northern Europe and western Siberia or over the greater part of North America. The observations which have been made of the microseisms over such large areas show that the amplitudes of the earth waves diminish as the disturbances are propagated to greater distances; for example, the amplitudes may exceed 10μ at 500 miles from the storm centre and fall off to 2μ at 2,000 miles.

The most satisfactory records for the study of microseisms are those obtained from instruments which record photographically. In seismographs with mechanical registration there is friction between the stylus and the smoked sheet, which is neglected in the calculation of the ground movement corresponding with a given displacement on the record, and the amplitudes tend to be underestimated. The uncertainties due to friction add considerably to the difficulties of determining the genuine differences between the amplitudes in different regions. It has also been found that, at some observatories with seismographs recording mechanically, the amplitudes of the microseisms are systematically larger by day than in the night, although the amplitudes obtained with photographic recording do not show any regular variations throughout the 24 hours. Dr. Whipple has suggested that the friction, inherent with mechanical registration, may change regularly, being overcome by day when there are very rapid oscillations of the ground due to traffic, etc. The diurnal variations would be greatest at observatories subject to these influences; examples supporting this suggestion are found at Copenhagen where with little disturbance near the seismographs there are no diurnal variations, and at Hamburg where traffic passes near the observatory and the variations are large.

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* The amplitudes are expressed in microns, the micron (1μ) being 0·001 mm.

Lord Rayleigh was responsible in 1881 for the development of the theory of propagation of waves along the surface of a solid. The

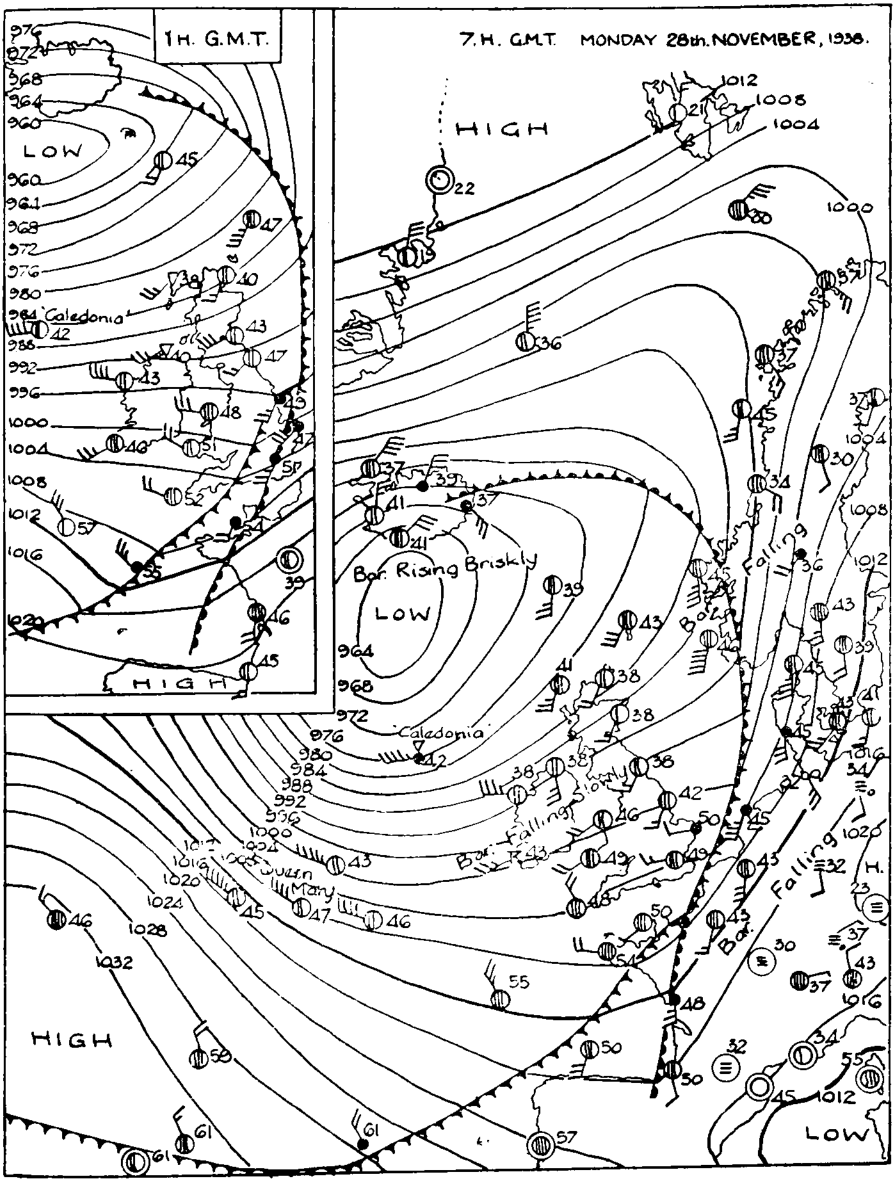

1 H. G.M.T.
7. H. G.M.T. MONDAY 28th. NOVEMBER, 1938.
LOW
HIGH
Caledonia
Bar. Rising Briskly
Bar. Falling
Bar. Falling Slowly
Queen Mary
H.
976
972
968
964
960
984
988
992
996
1000
1004
1008
1012
1016
1020
1024
1028
1032

FIG. 2.—SYNOPTIC CHARTS, NOVEMBER 28TH, 1938

(See explanatory notes on page 141)

waves he investigated are in some respects analogous to gravity waves on water, but for a solid the wave motion is controlled by the elastic properties instead of by gravity; the motion of the particles, as the waves pass a given point, is in the vertical plane containing the direction of propagation. From comparisons between the horizontal and vertical components of the microseisms it has been demonstrated that the movements are elastic waves of Rayleigh type travelling through the outer layers of the earth's crust. These waves are subject to changes of type according to the local geological conditions, being large at a place like de Bilt on weak formations and small at one like Abisko on rock. In preparing maps, of the type shown in Figs. 3 & 4, to represent the microseismic distributions for particular occasions, it is necessary to make allowance for the effects of local conditions. The amplitude shown on one of these maps for any particular observatory is intended to be that which would have been recorded if the surface layers in the vicinity had been transformed into solid rock.

In Rayleigh waves the earth particles move round ellipses or circles in a vertical plane, and the direction of motion is opposite to that of a point on a wheel rolling along the ground in the direction of propagation of the waves. Thus if Rayleigh waves are coming from the west the earth moves in succession eastwards, upwards, westwards and downwards. We may say that the vertical component of motion lags 90° behind the east component. Actually the phase differences between the components are variable but the values appropriate for the general direction of approach are dominant. The method has been applied to determine the direction of approach of the microseisms shown in Fig. 1; in a sequence of 50 phase comparisons at minute intervals from 6h. 35m. to 7h. 24m. on November 28th, 1938, the vertical component tended to be 90° in advance of the north component and 90° behind the east component; this result implies that the microseisms were then reaching Kew from the north-west, the direction to the centre of the depression which was the most conspicuous feature of the weather map for that time (Fig. 2).

The general similarity between the characteristics of the microseisms and those of the sea waves, and especially the close agreement between the periods, led to the belief that the phenomena are related, and the theories which have been propounded to explain the origin of microseisms have mostly endeavoured to show how they could be generated from the waves caused by depressions over adjacent seas.

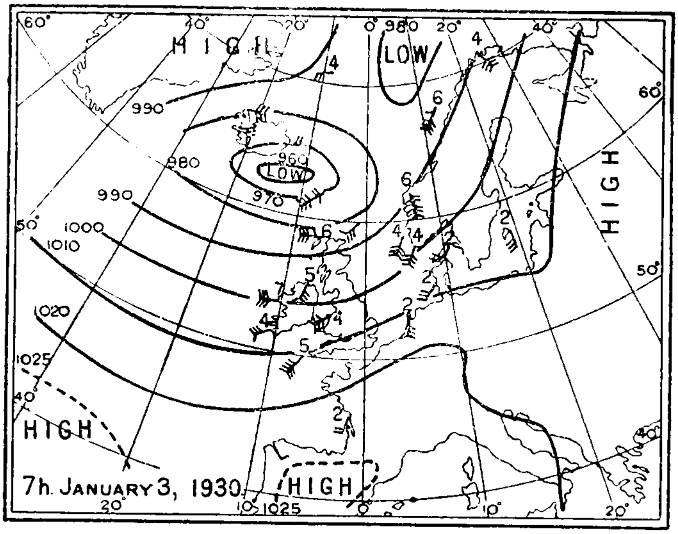
The best known hypothesis was developed by Wiechert, Linke and Gutenberg. The microseisms are attributed to the sea waves breaking on steep rocky coasts. Gutenberg believes that the microseisms are best developed in Europe and in North America when depressions are situated off the coasts, and that storms over the continents do not generate microseisms. He claims that the large microseisms recorded in Europe are mainly caused by the beating of waves along the precipitous western coast of Norway. A steep rocky coast is postulated in this hypothesis to ensure that the waves break violently and transfer the energy to the ground with a minimum amount of friction. Gutenberg has considered the order of magnitude of the quantities involved in the process and concludes that the energy transferred to the coast by the breakers is large enough to cause the microseisms. No exact explanation of how the surf sets the ground in oscillation is given, but presumably Gutenberg envisages each breaker as a tiny earthquake generating surface waves. A difficulty at once confronts such an hypothesis, for the impact of the waves would not occur simultaneously along the whole coastline affected, and consequently the agreement between the periods of the microseisms and of the sea waves is not explained.

Among the opponents of this hypothesis are S. K. Banerji and E. Gherzi, who have noted occasions on which large microseisms were recorded when the seas near the coasts were undisturbed. Banerji has shown that with a storm approaching India from the Bay of Bengal the largest microseisms occur several hours before it reaches the coast, and that the microseisms diminish when it crosses the coastline. To explain these observations Banerji put forward the hypothesis that the sea waves cause changes of pressure over the sea bed, thus setting up forced oscillations which are propagated as microseisms when they reach the coast. The difficulty encountered in this type of explanation is that the sea waves are superficial phenomena and diminish rapidly with the depth ; this is illustrated, for example, from experience with submarines. Gherzi has shown that large microseisms are recorded at Zi-Ka-Wei in China when there are cyclones in the surrounding regions, but not when the sea waves are due to high monsoon winds. The hypothesis which he put forward, and which has been elaborated by D. Bradford, is that the microseisms are caused by atmospheric oscillations or " pumping " near the centre of a cyclone. It is thought that the atmospheric oscillations not only generate microseisms when the storms pass over the land, but that they are also effective over the oceans, the oscillations being propagated through the water to the sea-bed and there transformed into microseisms.

The connexion between microseisms and weather is so well established that in some parts of the Far East the observations of microseisms give indications of the development of storms over the oceans and are a valuable aid in forecasting. Observations of microseisms at de Bilt were utilised in Holland during the war when meteorological reports for the Atlantic were not available, and the method was found to be useful under these difficult conditions. Really satisfactory results cannot be expected, however, from such applications until the mechanism of the production of microseisms is better understood, and there are some perplexing characteristics which are inexplicable with the current hypothesis. The deep depression, appropriately situated, is a necessary condition for the development of microseisms, but some other agency or combination of circumstances must be involved, and at present we have no idea of what this can be. The difficulty is apparent from our maps for

November 28th, 1938 (Fig. 2); from 1h. to 7h. on that day, while the microseisms were increasing, there was not any change in the

PRESSURE, WIND AND SEA DISTURBANCE


HIGH
LOW
LOW
HIGH
HIGH
HIGH
990
980
960
970
990
1000
1010
1020
1025
1025
60°
50°
40°
60°
50°
40°
20°
0°
10°
20°
7h. JANUARY 3, 1930

HORIZONTAL "STANDARD AMPLITUDES" OF THE MICROSEISMS

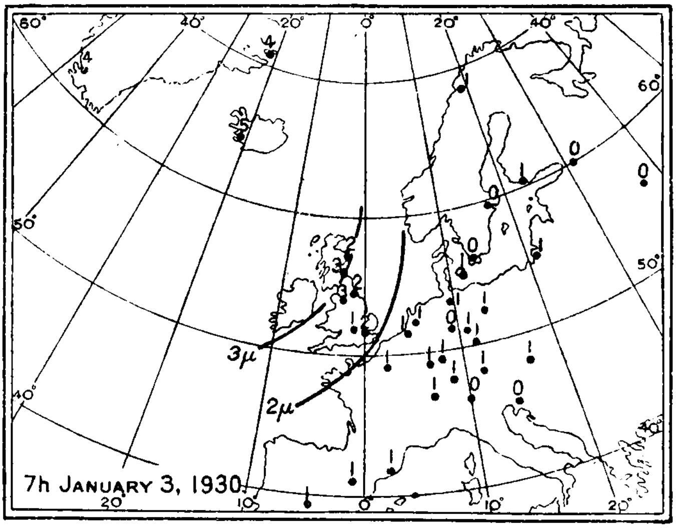

3μ
2μ
60°
50°
40°
60°
50°
40°
20°
0°
10°
20°
7h JANUARY 3, 1930

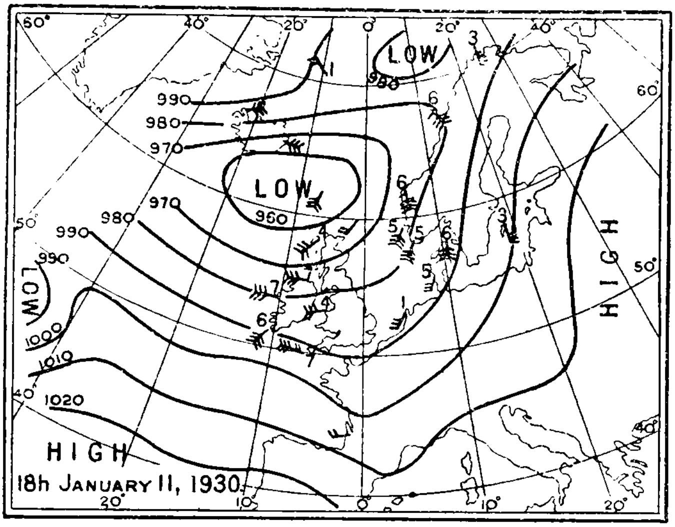
FIG. 3.—METEOROLOGICAL CONDITIONS AND PREVALENCE OF MICROSEISMS

(Pair of charts for January 3rd, 1930)

intensity of the depression south of Iceland and the winds over the British Isles were diminishing.

Moreover, deep depressions, of the same type and located over the same parts of the oceans, are not equally effective in producing

PRESSURE, WIND AND SEA DISTURBANCE


LOW
LOW
LOW
HIGH
HIGH
990
980
970
960
980
970
980
990
990
1000
1010
1020
18h JANUARY 11, 1930
60°
50°
40°
20°
10°
0°
10°
20°
40°

HORIZONTAL "STANDARD AMPLITUDES" OF THE MICROSEISMS

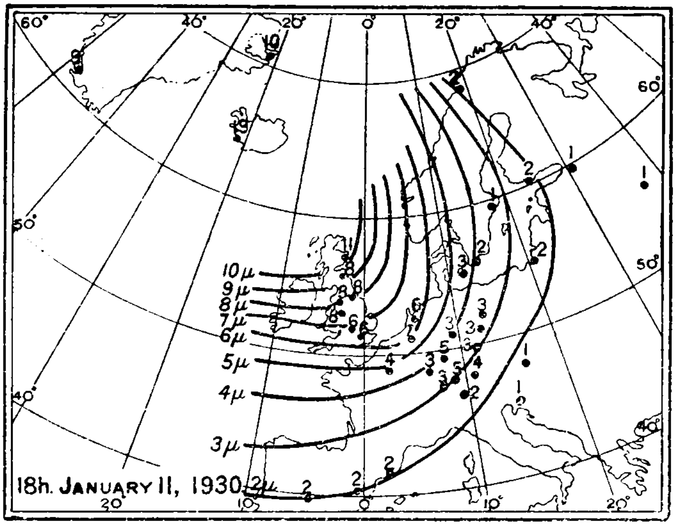

10μ
9μ
8μ
7μ
6μ
5μ
4μ
3μ
2μ
18h. JANUARY 11, 1930
60°
50°
40°
20°
10°
0°
10°
20°
40°

FIG. 4.—METEOROLOGICAL CONDITIONS AND PREVALENCE OF MICROSEISMS

(Pair of charts for January 11th, 1930)

microseisms. An excellent example is found in a comparison of the conditions round north-western Europe on January 3rd and January

11th, 1930. The synoptic charts and maps of the microseismic distributions for these two occasions are shown in Figs. 3 & 4. The synoptic charts for the two days are very similar, each showing a deep depression between Scotland and Iceland and a secondary off northern Norway, with strong winds and rough seas round north-west Europe. The lines of equal microseismic activity conform with the run of the isobars, but there is a striking contrast between the amplitudes of the microseisms, those for the earlier occasion being only about a third of those for the latter. Similar anomalies have been noticed in other parts of the world, and until these can be explained the problem of microseisms remains a challenge to meteorologists and seismologists alike.

PRESENTATION TO MR. R. G. K. LEMPFERT

Mr. R. G. K. Lempfert, Assistant Director of the Meteorological Office, retired on Saturday, December 31st, 1938, after more than 36 years service. A presentation from the staff of the Office was made to Mr. Lempfert in the Library at South Kensington on December 30th.

Mr. N. K. Johnson, Director, presided and spoke of his own indebtedness to Mr. Lempfert for his assistance during the preceding 4 months ; and of the reputation for courtesy which Mr. Lempfert had gained. He then asked Mr. E. Gold, Assistant Director, who had been for so many years a colleague of Mr. Lempfert's, and Mr. Tarrant, who entered the office a few days before Mr. Lempfert, to speak. Mr. Gold said :

"Mr. Lempfert entered the Meteorological Office on May 1st, 1902—as Scientific Assistant to the Director, Dr. W. N. Shaw—particularly for scientific investigations with reference to forecasts of weather. He had been one of the workers at the Cavendish Laboratory in the Golden Lustrum 1896–1900 when among others, Langevin, Lyman, McLennan, Zeleny, the Wilsons—H. A. and C. T. R., Townsend, V. W. Richardson and Ernest Rutherford were there. He was soon busy in the Office completing Carpenter's London Fog Inquiry, investigating with Dr. H. R. Mill a fall of red rain and arranging for experiments with a captive balloon at Bushy House to provide information about the vertical distribution in fog.

The fog report called attention to the gravity and difficulty of the various problems associated with the atmosphere of London and the extent to which they are aggravated by the common practice of the inhabitants as regards the production of smoke. The red constituent of the red rain was traced back to North West Africa—by the method of trajectories—then being explored by Lempfert and Shaw. The balloon blew away with its instruments to the north coast of France, whence it was subsequently brought back in a somewhat damaged condition by Mr. Pigeon, Master of the coasting schooner *Eagle*—an appropriate example of our national capacity for arranging a humorous setting for events which might be "cause for tears". The investigation culminated in the "Life History of Surface Air Currents", the classic foundation of frontal and air-mass meteorology.

R. G. K. Lempfert, C.B.E., M.A.

Although it had been expressly stated when the Scientific Assistant to the Director was appointed, that he was not expected to take part in the administration of the office, he was soon inspecting stations, and on July 31st, 1905, he became acting Superintendent of Instruments. In 1906 (March 31st) he became Superintendent of Statistics, and in that capacity I first met him and learned from him that the correct way for me to reply to letters was to impute my own lame efforts to the Director by beginning: " I am instructed by the Director to ....". It was Lempfert, too, who introduced me to the Royal Meteorological Society.

In 1910 (October 1st) he became Superintendent of the Forecast Division—in the then palatial new office, whose polished floor induced a passion for cyclo-strophic motion. I think he was the first to introduce to the Division the idea that the smoothest curves were not necessarily the best isobars, and that observations which indicated a discontinuity of direction in the isobars were not due to the observer's ignorance and incompetence, but constituted an important aid to forecasting. Naturally it was not easy for him to get new ideas put into operation—it never is. Almost before he could turn round he had to adapt the service to millibars and millimetres, and no sooner were the new arrangements running smoothly than the war came—and all the developments which observations from the Atlantic offered were arrested. If the synoptic meteorologist of to-day—accustomed as he is to extensive charts every 6 hours and intermediate charts for smaller areas—could look at the charts of 1915, he might wonder how any forecast in those days could be right. Well, Mr. Lempfert produced the goods—organized 1 a.m. reports, comforted those in anxiety or distress, and showed a considerateness and approachableness which made everyone go to him for advice and help in their difficulties. (I still treasure the pocket medicine case he gave me in 1915 when I left for a half-known destination.)

In 1919 he was made Assistant Director. In the new organisation he became responsible for personnel and publications—among other things. In the first his insight into character and his considerateness have earned him the affection and respect of all and in the second his early training in physics and his wide experience in all the branches of meteorology have been of the greatest service to the increasing number of authors of scientific memoirs among the staff of the office.

One or two incidents—Lempfert was the first to give meteorological lectures for airmen—at the Central Flying School, Upavon, when Trenchard (now Lord Trenchard) was Commandant—and we all gathered to celebrate their successful conclusion by a dinner paid for out of the honorarium. The balance I believe went in a fiddle.

I remember when Dr. Hesselberg, now President of the International Meteorological Committee, proposed in 1925 to resign from his position as Secretary of the International Upper Air Commission, and was besought to continue, he agreed only on condition that Mr. Lempfert would be Joint Secretary with him—and that was typical. "

Mr. Tarrant referred especially to the early days when a typewriter was a person and not a machine, and to the introduction o night work in the Forecast Division during the war, when the tediun of intervals between the preparation of forecasts and reports wa relieved by violin solos.

Mr. Johnson then asked Mr. Lempfert to accept a book of signature of the staff and a cheque, with the good wishes of all.

Mr. Lempfert in reply expressed his appreciation of the gift, and referred to the happy relations which he had always had with the staff.

The proceedings terminated with a presentation to Mrs. Lempfert in recognition of her contributions to the success of many social functions of the office.

MR. R. CORLESS

Following upon the retirement of Mr. R. G. K. Lempfert, Mr. R. Corless was promoted to the rank of Assistant Director of the Meteorological Office as from January 1st, 1939. Mr. Corless is a native of Lancashire and entered the Preston Grammar School in 1897. He proceeded to Cambridge as a Scholar of Sidney Sussex College in 1903, and took his B.A. degree in 1906, proceeding later to M.A. In the Mathematical Tripos, Part I, 1906, he was sixteenth wrangler and he also obtained a First Class, Natural Sciences Tripos, Part I, 1907.

Mr. Corless joined the staff of the Meteorological Office in October, 1907, as Special Assistant to the Director, Dr. W. N. Shaw (now Sir Napier Shaw). He became Clerk of Publications in 1910 and Secretary to the Director in 1913. After serving for a time as Acting Superintendent of Statistics, Mr. Corless was appointed Superintendent of Instruments in 1916. Under war conditions there was a great increase in the scope of the work of the Instruments Division, and Mr. Corless's services were recognized by the award of the Order of the British Empire (O.B.E.) in 1918. Since the war he has occupied in succession the posts of Superintendent of the British Climatology Division and British Rainfall Organization (1925), the Forecast Division (1929) and the combined Forecast and Aviation Divisions (1934). He was Secretary of the Royal Meteorological Society from 1924 to 1926 and Vice-President in 1927.

Among the papers of which Mr. Corless was author or joint author, special references may be made to the paper on " Line Squalls and Associated Phenomena " written in collaboration with Mr. R. G. K. Lempfert and published in Q.J.R. Meteor Soc., 1910, page 135.

During his long and varied career Mr. Corless has gained practical experience of nearly every aspect of meteorological work and we wish him all success in his new post.

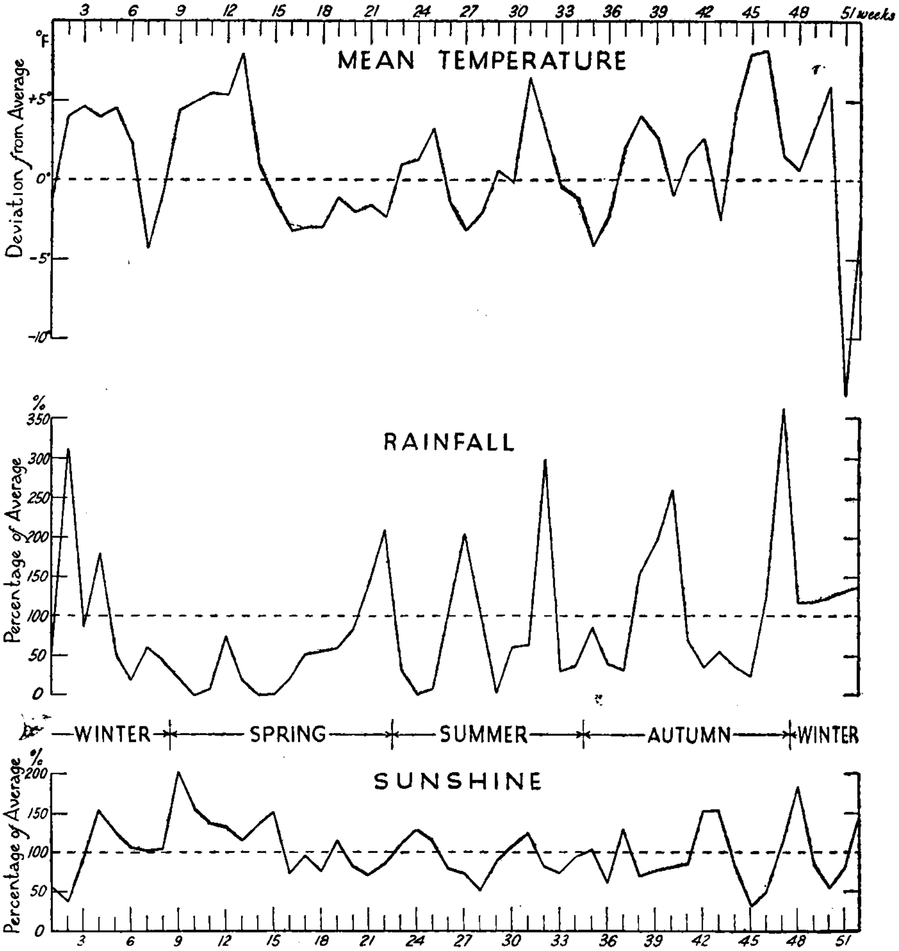
R. Corless, O.B.E., M.A.

The Weather of 1938

Great variability marked the weather of the year in the British Isles. Among the most notable features were the magnificent display of aurora observed throughout the British Isles on the evening of January 25th, the exceptional mildness of March and November, the drought of February to April, the severe gales at the beginning and end of June, the remarkable series of thunderstorms during the period August 1st to 12th and the severe frost and widespread snow of December 17th to 26th. From the limited information at present available it appears that mean temperature for the year exceeded the average generally, while sunshine was below the average on the whole, though an excess occurred in some small scattered areas. A detailed description of the rainfall distribution is given in a subsequent article.

Mean temperature for the year exceeded the average. Of the individual months, May and July were cool and mean temperature in December was also below the average owing to an exceptionally severe spell of wintry weather from the 17th to the 26th. The coolness of May was most marked in the east and south-east of England, while that of July was most pronounced in Ireland and in the western half of England. Keen frosts were registered at times during the first ten days of May; a screen minimum of 18° F. was recorded at Braemar on the 2nd and at Thetford, Norfolk, on the 8th. During the cold spell of the 17th to 26th of December, temperature was continuously below the freezing point in some areas for several days. In the other nine months temperature exceeded the average on the whole though April was cool in east and south-east England and June in Ireland and west Scotland, while during a cold spell in February snow lay continuously at Canterbury from the evening of the 13th to the morning of the 18th. March, November and the first half of December were unusually mild. March was by far the warmest March on record for the British Isles generally and November was also exceptionally mild. In many places the absolute maximum temperature recorded in November, registered as a rule on the 4th, 5th or 6th, was the highest on record for November; at a number of stations in east and south-east England 70° F. was registered on the 5th. January was also mild; at numerous places in England, temperature in the screen did not fall to 32° F. throughout the month. A warm spell occurred during the first 12 days of August; a maximum temperature of 80° F. or above was registered at some station or other on each of these days. The highest temperature of the year was recorded in each country during this spell, namely 87° F. at Camden Square (London) and at Reading on the 1st, 82° F. at Ardtornish and Ruthwell on the 10th and at Fort Augustus, Kilmarnock and Forres on the 11th and 78° F. at Birr Castle and Foynes on the 3rd.

Sunshine was almost everywhere deficient; there was an excess, however, in parts of Scotland, at a few places in south-east England and locally in north-west England. January was sunny in east Scotland and north-east England but excessively dull locally in the north of Ireland, March was unusually sunny in east and south-east England and the Midlands and markedly dull in the west and north of Scotland and April was exceptionally sunny in western districts.



THE WEATHER IN 1938 IN SOUTH-EAST ENGLAND

Weekly variations from long period averages computed from observations at five representative stations.

The summer months May to September were dull on the whole, particularly July; a notable excess was enjoyed, however, in Scotland and locally in north Ireland in August. Broadly speaking, in October, sunshine exceeded the average in the eastern districts of Great Britain and the Midland counties of England and was somewhat deficient in the west. In November sunshine was very variable, and December was mainly sunny; at Valentia Observatory it was the sunniest December in a record back to 1880.

Gales occurred frequently during the year and were unusually severe at times. Amongst the highest speeds recorded in gusts were 108 m.p.h. at St. Ann's Head, Pembroke on November 23rd, 104 m.p.h. at St. Ann's Head on October 4th, 101 m.p.h. at St. Ann's Head on January 15th and at Bidston on January 29th and 100 m.p.h. at Kirkwall on January 23rd. The gales of January 14th to 15th, of June 1st to 2nd and 27th to 29th and of November 23rd are described on pages 4, 139 and 306.

The diagram on page 328 shows the weekly variations in temperature, rainfall and sunshine in south-east England in 1938. The variations are given in the form of deviation from the average of temperature and percentages of the average of rainfall and sunshine. The district value is the arithmetic mean of the values for the following stations:—Kew Observatory, Margate, Hastings, Southampton and Marlborough.

L. F. Lewis.

The Rainfall of 1938

The rainfall of 1938 presents features of unusual interest, both as regards the incidence of rainfall throughout the year and the variation in the annual totals from place to place. Over the British Isles generally the three months February to April were unusually dry; the summer months May, June and July gave more than the average, June being especially wet in Scotland; while October and November were unusually wet.

The distribution of the rainfall in 1938 stands out in sharp contrast with that of the previous year, when January to May gave more rain than in any similar period back to 1870, while for the remainder of the year dry months predominated. A comparison of the rainfall during the two years for the periods January to May and June to December is given below:—

	British Isles.	
	Jan-May	*June-December*
	in.	in.
Average...	15·4	26·0
1937	21·9	21·2
1938	13·2	32·3

General values for each month are set out in the following table, both as percentages of the average and in inches of rainfall.

The rainfall of March was most remarkable over England and Wales. The general rainfall was 0·7 in., the smallest value for March since 1870 with but two exceptions *viz.* those of 1893 and 1929 with 0.6 in. and 0·3 in. respectively. The general rainfall for April over England and Wales amounted to only 0·3 in. and so far as can be ascertained April, 1938 was the driest April since before 1727. The driest months since 1870 are February, 1891, June, 1925, April, 1912 and March, 1929 with 0·1, 0·1, 0·3 and 0·3 in. respectively. April, 1938 ranks therefore amongst the five driest months on record since 1870. The rainfall of the three months

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	%	%	%	%	%	%	%	%	%	%	%	%
England and Wales	147	52	27	13	124	96	115	100	94	126	141	121
Scotland ...	162	80	97	34	136	201	143	68	127	186	157	84
Ireland	144	66	65	7	139	155	163	83	105	193	156	105
British Isles ...	150	62	52	17	130	133	132	89	105	154	147	109
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
England and Wales	4·4	1·3	·7	·3	2·9	2·3	3·3	3·4	2·4	5·0	4·9	4·7
Scotland ...	7·9	3·4	3·9	1·0	4·1	5·7	5·4	3·1	5·1	9·1	8·3	4·9
Ireland	5·8	2·3	2·2	·2	3·8	4·4	5·5	3·5	3·3	7·9	6·7	5·2
British Isles ...	5·7	2·0	1·7	·4	3·4	3·5	4·3	3·4	3·2	6·6	6·2	5·1

February to April, 1938 over England and Wales amounted to only 2·3 in., less than in any similar period back to 1785, when the general rainfall was estimated to be 2·1 in. Further details of this spring drought are given on pp. 81–84.

The general rainfall over the British Isles for October and November was 12·8 in., exceeding that for any similar period since before 1870, the October and November of 1929 giving 12·6 in.

The range in the monthly totals reported during the year was from 0 to 50 inches. During the whole of April numerous areas in southern Ireland, in parts of Hampshire, Dorset, Cornwall and Pembroke received no measurable rain. On the other hand as much as 50·03 in. was recorded at Loan, above Loch Quoich, in Inverness-shire for March.

Of the daily amounts recorded during the year mention should be made of the following :—

Watendlath Farm, Cumberland ...	5·95 in.	July 29th.
Torquay (Abbey Gardens) Devon...	5·61 in.	August 3rd.
Kinlochquoich, Inverness-shire ...	5·35 in.	February 3rd.
East Overton House, Lanark ...	5·10 in.	August 11th.

Details of the thunderstorm rains of August 1st to 12th are given on pp. 202–4.

Provisional estimates of the general rainfall for 1938 are given below, both in actual inches and as percentages of the average :—

	in.	Per cent.
England and Wales	35·6	101
Scotland...	61·9	123
Ireland	50·8	117
British Isles	45·5	110

The rainfall over Scotland was most remarkable. Only four years since 1870 were as wet or wetter than 1938, viz., 1872, 1877, 1903 and 1928 with 134, 131, 129 and 123 per cent. respectively. Over both Ireland and the British Isles as a whole 1938 ranks as the wettest year since 1930. The rainfall over England and Wales slightly exceeded the average, but was less than that since 1934.

Falls of less than 80 per cent. were confined to the east of Norfolk, east Berkshire and the north of Hampshire. There was less than the average over most of England to the south of a line from Liverpool to Lincoln, near Durham, Berwick-on-Tweed, in the north of Aberdeenshire and Banffshire, and near Cork. Over most of Devon and Cornwall, however, the totals exceeded the average, more than 110 per cent. being recorded from Bideford to Torquay, in the region of heavy rain on August 3rd and 4th. Over the Pennines and the area to the west the rainfall exceeded 110 per cent. and there was more than 130 per cent. in the English Lake District. At Keswick, October and November together gave 28·3 in. or more than half the average for the whole year. October, 1938 ranks as the wettest month on record there since December, 1852.

The rainfall exceeded the average over most of Wales, and there was more than 110 per cent. along the south coast and from Montgomery to Anglesey. The totals over the western half of Scotland generally exceeded 120 per cent. and large areas received more than 150 per cent. near Paisley and from Fort William to Inveraray. At Inveraray Castle the total was 143·8 in. and 66·6 in. or 86 per cent. in excess of the average. In Ireland the percentages were generally greater in the west and north, where values exceeding 120 per cent. were widespread. There was more than 130 per cent. at Limerick, Birr Castle, Londonderry and to the north-west of Galway.

In parts of the Western Highlands of Scotland 1938 ranks as the wettest year since before 1868. The value of 186 per cent. for Inveraray Castle is, so far as can be ascertained, the largest value for any station since before 1868. The wettest period was the 60 days, October 2nd to November 30th, with 44·0 in. or 57 per cent. of the average for the whole year. The 12 days, October 2nd to 13th, gave 14·1 in. or more than one-sixth of the annual average.

J. GLASSPOOLE

Royal Meteorological Society

By arrangement with Messrs. Science Films, Ltd., the usual monthly meeting of the Society was held on Thursday, December 15th, 1938, at the Gaumont British Theatre, Film House, Wardour Street, London, W.1. Dr. B. A. Keen, F.R.S., President, was in the Chair.

By the courtesy of the Air Council, two meteorological instructional sound films, "Fog" and "Ice Formation", were shown. These were followed by a discussion.

The Physics of the Atmosphere

By Professor D. Brunt

The making of a research meteorologist is a long, often tedious, and sometimes painful process. The young man who aspires to become a research worker in meteorology must first master the general outlines of the physics and dynamics of the atmosphere, while also acquiring a clear idea of the limitations of the methods of observation used in meteorology. When, in the next stage of his progress, he desires to acquire more than a textbook acquaintance with some particular branch of the subject in which he wishes to specialise, he finds the most serious obstacle to progress in the lack of a complete and reasonably compact account of this branch. In pure physics the needs of the research worker have been largely met by such series of books as Methuen's monographs, and the *Reports on Progress in Physics* published by the Physical Society of London. But in meteorology the corresponding needs have in the past been very inadequately provided for. The book under review meets this want in five sections of the Physics of the Atmosphere.*

The present volume, the third of the series, entitled *Ergebnisse der kosmischen Physik*, under the general editorship of Dr. V. Conrad of Vienna, is in five sections, each by a different author, dealing respectively with the physics of the higher atmosphere, the investigation of cosmic rays during the last five years, "Dämmerungsforschung," atmospheric condensation nuclei, and the vertical distribution of ozone.

The first section, by J. Zenneck of Munich, deals mainly with the ionosphere, describing the methods of investigation, the measurements which have been made of the ionisation, the difference between ionisation by waves and corpuscles, the distinction between the corpuscular and visual eclipses of the sun, and the interpretation of the variations of ionisation in terms of the variations of pressure and temperature in the upper layers of the atmosphere.

In the second section, R. Steinmaurer of Innsbruck describes the advances made in the investigation of cosmic rays during the last five years. These advances he describes as in the main consisting of an increased knowledge of the facts of observation, the ultimate problem of the origin of the rays and of the exact nature of their interaction with matter being still obscure.

In the third section, P. Gruner of Berne describes the study of the changes in colour of parts of the sky when the sun is below the horizon, including sunset glows, the purple light, and the brightness of the night sky. These are parts of what is known in German as "Dämmerungsforschung".

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* *Ergebnisse der kosmischen Physik,* **III**, hrsg. von V. Conrad. Leipzig, Akademische Verlagsgesellschaft, M.B.H.

The fourth section alone is written in English, and is by H. Landsberg of Pennsylvania. It deals with condensation nuclei, and gives by far the most comprehensive account of what is known of their nature, distribution and effects on condensation. The author begins with a discussion of the physical process of condensation, considering in turn the effects of curvature of the surface, hygroscopic action, and electric charge. The origin and chemistry of nuclei are then discussed, and the author gives a very complete account of the methods used for the observation of nuclei, the diurnal and annual variation of their number, their distribution over the globe, and their correlation with other meteorological factors. An appendix gives a table of nuclear concentrations made by various authors at 170 land stations, and in 36 oceanic areas.

In the fifth section, by F. W. Paul Götz, we find a very complete discussion of the vertical distribution of ozone in the atmosphere. The author begins with a valuable discussion of the spectrum of ozone in the ultra-violet, in the Chappuis bands in the green, and in the infra-red, followed by a description of the spectrum of oxygen in the far ultra-violet. These descriptions of spectra are very pertinent to the discussion which follows, but are not readily accessible to most readers. The account which follows, of the latest methods used for the observation of ozone in the atmosphere, and of the theory of the interpretation of the observations of ozone absorption in terms of the vertical distribution, is in sufficient detail to enable the reader to understand the details of the computation of the vertical distribution of ozone. It will be noted that the different methods of observations, whether by measurement of absorption made at the ground, as is done by Dobson and his collaborators, by spectographs sent up on sounding balloons, as is done by Regener, or by direct photography of the spectrum, as was done on board the *Explorer II*, the American stratosphere balloon, all lead to substantially the same distribution of ozone in the vertical. The theories of the formation and distribution of ozone due to Chapman and to Mecke, and the computations of the effect of ozone absorption on the vertical distribution of temperature in the atmosphere, are also briefly but clearly summarised.

It is not possible in the space available in a review to summarise effectively the contents of a volume which might itself be described as a summary of a vast amount of work in the fields of activity mentioned, and all that can be done is to give an indication of the scope of the volume. The literature of the subjects covered in this volume has hitherto only been available in a scattered form, often in publications which are not readily available to most readers. The editor of the book may, therefore, be congratulated on having produced a volume which will meet the needs of many workers, and will not fail to provide a stimulus for further research into the many problems discussed in it. The five sections are each followed by a bibliography, which total over 1,700 references. This may be taken as some indication of the amount of work involved in the compilation of this volume.

Correspondence

To the Editor, *Meteorological Magazine*

Snow in the Chiltern Hills after Thaw

On December 29th, 1938, there was just the right amount of snow left from the heavy Christmas falls in the south-east of England to show up interesting topographical relationships. Thus in the course of a railway journey from London to High Wycombe and back on that date it was noticeable that the amount of snow lying about was greater around High Wycombe in accordance with general increase of altitude in the heart of the Chilterns than nearer London. On the other hand all the Chiltern " bottoms " which are so well developed around High Wycombe contained much larger and thicker patches of snow than the ridges and open table-land. The explanation of this interesting inversion of the normal altitudinal distribution of snow-cover is, no doubt, that the " bottoms " were more sheltered from the damp thaw winds and also more exposed to the ground frosts which occurred every night during the rather cold thaw. Had the snowfalls occurred with high wind the effect might have been attributed in part to mass drifting, but the easterly gales had subsided when the first heavy snowfall of December 21st came. But whatever the correct explanation the fact emphasizes two important principles : firstly, the importance in questions of snow-cover of associating mere altitude above sea-level with surrounding configuration ; secondly, the importance in all climatological questions of remembering that hill or mountain valleys are an integral part of the uplands themselves. The common loose phraseology merely opposing " hills " to " valleys " regardless of whether the latter are lowland vales or hill-country dales or mountain ravines is painfully ungeographical.

L. C. W. BONACINA

13, Christchurch Hill, Hampstead, N.W.3
December 30th, 1938.

" From Up to Up "

The following letter has been forwarded by Mr. D. E. Smith of the Nigerian Meteorological Service, in the hope that one of our readers may be able to furnish an explanation.

> The Education Officer's house here is near the top of a hill and some 1,500 feet above sea level. Some three or four years ago my wife and I heard rain falling, but looking all around we could see no place where it was raining. The sound was as though it were quite near and *appeared to come from above where we stood.*

Mystified we turned to an intelligent Yoruba carpenter who was nearby and asked where it was raining. He replied, " From up to up,"(!) meaning from one cloud level on to another. There were certainly heavy tornado clouds all around and above us. We could scarcely believe this explanation and have always been rather curious about the matter.

I am writing to you now because on November 28th, 1938 I was staying here with three friends from Ilorin and we all heard exactly the same phenomenon at the same place. They were as sceptical as my wife and I, but could not think of an explanation. My steward gave the same explanation as the carpenter had done on the earlier occasion. It has occurred to me, however, that rain may have been falling at a distance and the sound was reflected from the heavy cloud above. I should be interested to know whether the " up to up " hypothesis is possible or not. J. D. Clarke,
Education Officer.

Ilorin, Nigeria, November 30th, 1938.

NOTES AND QUERIES

Height calculations : a simple method

In the October 1938 number of this Magazine, Mr. E. Gold gave an easy rule for finding the approximate height to which an observation of pressure and temperature in the upper atmosphere refers, but he left the explanation as an exercise for the enquiring student. One might in fact expect to be able to derive the height from the tephigram by means of the dry adiabatics, on which a given difference of temperature corresponds invariably with the same height interval; thus 10° F. corresponds with about 1,860 ft. An approximation to the height interval between any two pairs of readings (p_0, T_0), and (p_1, T_1) may then be obtained directly from the temperature difference intercepted between the isobars p_0 and p_1, on a dry adiabatic, a process which would be further facilitated by placing a suitable scale, reading height in place of temperature, along the adiabatic. If the adiabatic used is the one passing the lower point (p_0, T_0), then the estimated height is too small; if on the other hand the adiabatic passes through the upper point (p_1, T_1), the estimated height is too large. Evidently a correct result can be obtained by choosing an adiabatic in an intermediate position, roughly halfway between the two extremes, but its precise position will depend on the shape of the observed temperature-pressure curve.

A modification, which is more troublesome but more precise, is to evaluate the height by using a series of adiabatic steps :—starting from the lowest point on the observed curve, proceed along an adiabatic for an interval of 10° F., then return to the curve along an isobar, and repeat the process as often as necessary, finally converting the total adiabatic temperature drop into height. This process becomes theoretically exact when the stages are made indefinitely small.

It is easily seen that Gold's formula corresponds with the former of the above processes, with the adiabatic taken through the highest point; the positive error which results from applying the adiabatic lapse rate is compensated by reducing the equivalent of 10° F. to 1,800 ft.

As these methods depend in part on the adiabatic lapse rate, the precise value of this constant may be conveniently looked into here. It is expressed by either of the following formulae—

$$\frac{\gamma - 1}{\gamma} \cdot \frac{g}{R} \text{ or } \frac{g}{J\,c_p},$$

where $\gamma = Cp/Cv$ is the ratio of the specific heats of dry air, R is the gas constant, J the mechanical equivalent of heat, g the acceleration due to gravity, and also

$$R = J\,(c_p - c_v).$$

The formulae for the lapse rate are derived from the assumption that dry air behaves as a perfect gas. The value of J ($Cp - Cv$), $2{\cdot}8842 \times 10^6$, differs slightly from the value of R, $2{\cdot}8703 \times 10^6$, and indicates that the assumption of the characteristics of a perfect gas is not wholly justifiable.

A. F. CROSSLEY

Height calculation from the tephigram— Another simple method

Mr. Gold's method, given in the issue of this Magazine for October, 1938, for estimating approximate heights from the tephigram is delightful and will, no doubt, be tried out by many people working with the tephigram. Aviation meteorologists will have noticed that, as the estimate depends only on the pressure difference between the ground and the height of flight together with the temperature at that height, the formula performs precisely the same function as the " computor " used by the pilot to correct his altimeter reading for temperature. As is well known, no formula which takes account only of the temperature at the height of flight can be very accurate; the practical rule of allowing one part in 500 for each degree Fahrenheit by which the average air temperature below differs from that assumed in the construction of the altimeter computor, is sufficient to indicate the probable error of the corrected reading. Errors consistently less than 300 ft. at 20,000 ft. can hardly be claimed on this basis.

The following method, which as far as I know is novel, provides a very simple and theoretically accurate method of measuring height from the tephigram with perfect generality. The only errors are due to ignoring the effect of humidity on air density and to the limitations imposed by the scale of the chart. The precision is, in other words, similar to that of any other reading on the tephigram.

One of the properties of the tephigram noted by Sir Napier Shaw is that geodynamic height is represented by area. If, in Fig. 1, showing a portion of the tephigram, A and B are two points on a curve representing an upper air sounding, then the geodynamic height difference between them is given by the shaded area bounded by the curve AB and the two isobars through A and B continued down to the absolute zero of temperature. If now we draw between the same two isobars an adiabatic line CD cutting the curve at O in such a position that the area DOB = COA then, plainly, by the above proposition, the height between A and B is equal to the height of the isentropic atmosphere CD. But the height of an isentropic atmosphere is given by dividing the temperature range by the adiabetic lapse rate (5·4° F. per 1,000 ft. very accurately). Furthermore, the temperature scale on the tephigram is uniform and the height interval AB is represented simply and directly by the length of the line CD.

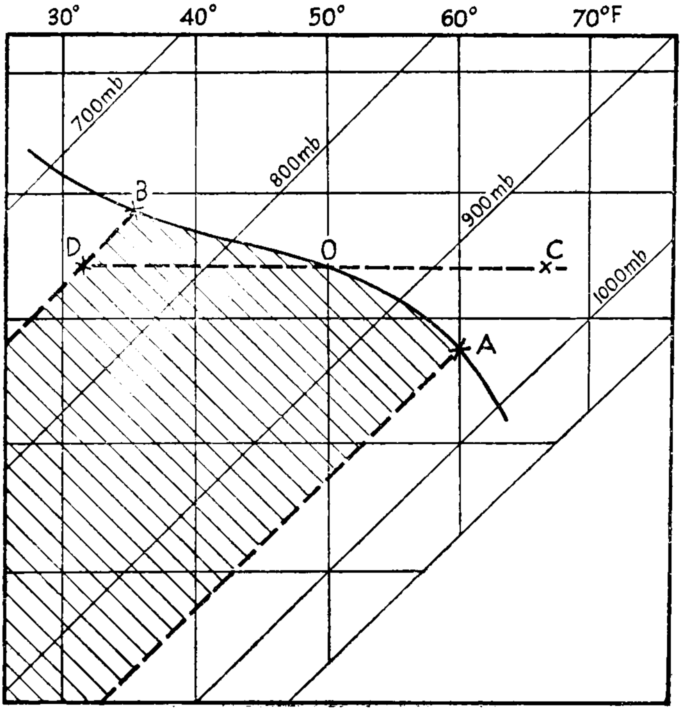

FIG. 1.—PORTION OF A TEPHIGRAM

In practice all that is desired is a transparent scale upon which is engraved an " adiabatic height scale " (1,000 ft. = 1·08 cm.).

R. C. SUTCLIFFE

Note on the above Communications

Mr. Crossley makes the interesting suggestion that the divergence between the values of the adiabatic lapse rate deduced from the two formulae is due to the divergence of dry air from a perfect gas. An alternative explanation may be that the determination of the values of the specific heats is less accurate than the determination of the ratio between them.

Mr. Sutcliffe remarks that the formulae I gave cannot be very accurate. Occasionally no doubt there will be appreciable errors. But it is surprising how accurate in fact the formula is. That is partly because the percentage errors arising from the formula are greatest at the lower levels. At altitudes of 15,000 and 20,000 ft. the percentage error is usually very small and the actual errors are practically within the tolerance of the instruments from which the basic values of pressure and temperature are obtained. If the average temperature gradient up to 20,000 ft. is 3·5° F. per 1,000 ft.—i.e. approximately the same as in the I.C.A.N. standard atmosphere—the error in my formula is practically nil.

I picked up one or two *Upper Air Supplements* to the *Daily Weather Report* at random and computed the height of the 500 mb. surface at Mildenhall from the formula. In the first case, November 19th, 1938, the height from the formula agreed exactly with the height given in the *Daily Weather Report.* In the second case, November 29th, 1938, the height from the formula was about 200 ft. less than that given in the *Daily Weather Report,* but in this case the height from the formula agreed within 100 ft. with the height found by using Mr. Sutcliffe's elegant geometric method and with the height found by step by step computation.

I then looked out two exceptional cases, October 31st and November 8th, and found the following results :—

Height of 500 *mb. surface above M.S.L.*

November 8*th,* 1938, *Mildenhall*

D.W.R.	18,870 ft.
Formula (E.G.)	19,070 ,,
Step by step computed	18,680 ,,
Estimated by Sutcliffe's method	18,500 ,,

October 31*st,* 1938

D.W.R.	18,530 ft.
Formula (E.G.)	18,600 ,,
Step by step computed	18,410 ,,
Estimated by Sutcliffe's method	18,220 ,,

The values " estimated by Sutcliffe's method " were derived from the formula given below.

The greatest error in the value given by the formula is less than 400 ft., even in the exceptional case of November 8th.

Nevertheless, I ought to make it clear that I did not put forward the formula as a strictly accurate formula but as a convenient approximate formula. No one could have been more surprised than myself at the accuracy with which it gave heights when applied to actual upper air ascents. The explanation is briefly this: the height given by the formula is represented by the length of a line parallel to the line DC in Mr. Sutcliffe's diagram but at a distance of about 3 cm. (15° F. of Potential Temperature on the tephigram) below the level of B. I think this method of interpreting the formula makes the reason for its accuracy clearer than Mr. Crossley's interpretation of it as representing the height by a line through B parallel to CD, but measured with an adjusted scale.

Owing to the variation in the dimensions of the paper of the tephigram—particularly with humidity—a greater accuracy can be obtained by reading the temperatures T_C, T_D, at the point C and D in Mr. Sutcliffe' diagram and using the formula

$$H = 1{,}000\,\frac{T_D - T_C}{5\cdot 4}$$

than by actual measurement with a scale. There are frequently errors of $\frac{1}{2}$ per cent. or more in the dimensions of the paper.

E. Gold

Measuring a Halo with a Theodolite

From time to time accounts are published in the *Meteorological Magazine* of unusual halos or other optical phenomena. In some cases the account includes measurements made by means of a theodolite of the type normally used for pilot balloon observations. Following upon the account, in our October issue, of an elliptical halo observed at Leuchars on May 30th, 1938, we have received a letter from Mr. A. E. Mayers (Linton-on-Ouse) pointing out that an error was made in determining the horizontal diameter. As the source of error may not be familiar to some readers of the Magazine, we think it worth while to direct attention to it here.

If a theodolite is set up and adjusted in the usual way, the azimuth of any object at which the telescope is pointed is given by reading on the horizontal circle. If azimuth readings are taken successively on the left and right margins of a halo, it seems natural to assume that the difference in the readings represents the angular horizontal diameter of the halo. That assumption is, however, incorrect. What we want to know is the angle subtended by the horizontal diameter, measured in the plane containing the diameter and the point of observation. This plane is inclined to the horizontal at an angle equal to the sun's altitude, and it is easily seen by simple geometry that the required relationship is

$$\tan \beta = \operatorname{Cos} \alpha \tan \beta'$$

where β is the true semi-diameter, α is the sun's altitude and β' is the apparent semi-diameter as measured on the horizontal circle of the theodolite. At Leuchars the theodolite measurement gave $\beta' = 32°$ and α was 43°. The corrected value of β works out at $24\frac{1}{2}$ and the halo was therefore only slightly elliptical.

It may be noted that the correct value would have been obtained directly if the telescope had been set at zero on the altitude scale, and the whole theodolite had then been inclined so as to bring the plane of the azimuth circle into coincidence with the plane containing the horizontal axis of the halo and the point of observation. On enquiry it was learnt that this method was actually adopted at Aberdeen, where an elliptical halo was also observed on May 30th (*see Met. Mag.* 1938, p. 775). It seems preferable, in general, however, to set up the theodolite in the normal way and apply the cosine correction.

Measurements made on the altitude circle of the theodolite do not require a correction of the type discussed above. Thus the vertical axis of a halo is measured directly by subtracting the altitude of the lower margin from the altitude of the upper margin.

Abnormal Weather in Iraq in July, 1938

It has been customary in the past to associate the summer in Iraq with cloudless skies, no precipitation, constant northwest winds, hot days and cool nights. This year, however, the weather has behaved in unusual fashion since there have been days when the sky has been practically overcast, heavy showers of rain have fallen, winds have been from the northeast and night minimum temperatures have been abnormally high. No parallel case of such a divergence from the normal could be found from an examination of the charts of previous years and it was considered that such unusual phenomena should be put on permanent record.

This year the sky was cloudless from May 25th except for traces of cirrus on June 11th, 13th and 14th, but on June 26th one tenth of altocumulus had formed by 0900 G.M.T., and the upper winds on that day had changed from northwest to between north and northeast. From then until July 16th, (with the exception of July 7th when the upper winds had temporarily returned to northwest and there was only a trace of cirrus in the sky) there was an average of five-tenths of cloud observed each day. On two occasions the sky was eight-tenths, and on one occasion nine-tenths, covered with cloud. Pilot balloon ascents were made at frequent intervals on July 7th, in connection with the long distance flight between Cranwell and the Persian Gulf so that the variations in upper winds could be observed more closely than usual. At 2040 G.M.T., the upper winds were northwest, while at 2245 G.M.T. they had veered to northeast, the surface wind still remaining northwest. With the arrival of these northeast upper winds, clouds were seen to form. It would appear that these northeast upper winds, while passing over the Iranian mountains (extending in places up to

12,000 feet, densely wooded and on which the snow was still melting), had become moisture laden and the formation of high strato-cumulus and medium cloud had subsequently resulted. Showers were reported during this period at various parts of the country. Heavy showers occurred at Baghdad on the evening of July 9th and slight showers at Habbaniya and Hilla. This is perhaps worthy of note in view of the fact that observations which have been kept at Baghdad since 1887 show that rain has never occurred before in July. An unpleasant consequence of these clouds being present at this time of the year was the fact that, at Habbaniya, the minimum temperatures were from 6°F. to 9°F. above normal. During this period the daily maximum temperatures were also above normal and on July 8th the temperature had reached 120°F. which, as far as can be traced, is the highest temperature recorded in Central Iraq at such an early date.

The simplest explanation which suggests itself to account for the unusual occurrence of northeast instead of northwest winds is that the permanent low which covers Baluchistan and Tibet in summer deepened more rapidly than usual and that the low pressure system which normally is stationary over southern Iran in summer deepened more slowly owing to the late melting of the snows. Hence, the latter acted as though it were a secondary to the former and moved in a counter-clockwise direction to a position over the Arabian desert, thus causing the winds to veer from northwest to northeast. The continued heating of the Iranian plateau caused this pseudo-secondary to move northwards again and the weather accordingly reverted to type on July 17th.

G. G. MACDONALD.

Christmas Weather, 1739

The following extract from the parish register of Saunderton, Bucks, has been forwarded by Mr. W. H. Challen of Carshalton. The note is recorded on the first parchment page of the register book 1729–1812, and is in the handwriting of Dr. Christopher Willoughby, Rector of Saunderton from September 13th, 1734, until his death in July, 1743, aged 47 :—

MEM : 1739

> " The Frost began on Christmas Day ; the Saturday, Sunday, and Monday following, Three the sharpest daies were ever known. Wind N.E.
>
> The Frost continued without any intermission till Saturday the 16 of Feb. when it began to thaw, but froze again all the next week till the Sunday following, when it thawed again & froze for some daies after.
>
> No Rain from the end of Harvest till the 12 of Apr. which lasted 3 daies, Apr. 20. It began to snow & continued for 3 daies.
>
> Frost lasted a Nights till the middle of May, on the 4 of the same month a good deal of Rain & on July 30 a thunder-shower after that no rain till sometime in Harvest."

January 6th, 1839. "The Great Wind"

A centenary broadcast on January 6th dramatised the storm of January 6th to 7th, 1839, which almost rivalled that of 1703 in the fury of the wind. In Northern Ireland houses were unroofed or swept away, chimney stacks blown down and many thousands of trees uprooted. Menai Suspension Bridge was damaged and many ships wrecked, with great loss of life. The gale sprang up rapidly from south-west but lasted for only a few hours. Details are lacking, but probably an exceptionally deep secondary depression passed quickly northeastwards along the north coast of Ireland and across Scotland, while pressure remained high to the southward.

An interesting account of the Liverpool hurricane of January, 1839, occurs in *The Times* of January 9th, 1939. In addition to great damage on shore, the Mersey was strewn with wrecks and many lives were lost. Snow, thunder and lightning occurred during the night and many fires resulted.

A point of interest is that sea-spray "incrusted windows half way across the Kingdom and whole hedges were carried away like chaff."

Mr. W. J. Gibson of Waringstown, Co. Down recalls that the pressure of the wind was 30 lbs. per sq. ft., which is equivalent to a velocity of about 100 miles an hour.

NEWS IN BRIEF

New Year's Honours.—We have pleasure in announcing that Miss D. G. Chambers, Assistant I in the Meteorological Office has been awarded the M.B.E., and that a Knighthood has been conferred upon Professor R. G. Stapledon of the University College of Wales and the Welsh Plant Breeding Station.

The Weather of December, 1938

The Siberian anticyclone extended far to the north-west over Finland and Scandinavia. At Moscow the mean pressure was 1036 mb., 18 mb. above normal; in northern Sweden 1026 mb. (+ 16 mb.) and Oslo 1021 mb. (+ 11 mb.). At the Azores the pressure of 1022 mb. was 1 mb. above normal, while the Icelandic low with 994 mb. was 3 to 4 mb. below. There was also an area of low pressure (— 5 mb.) over the Bay of Biscay. This distribution was favourable for abnormally strong southerly winds between Iceland and northern Siberia. In East Greenland, Jan Mayen, Norway and Spitsbergen the air supply came from the Atlantic Ocean and temperatures were from 5° to 16° F. above normal. Further east the air supply was derived from the continent of Europe and temperatures decreased rapidly. In Europe and the southern half of the British Isles the anticyclone over Finland caused easterly winds to predominate and temperatures were below normal, the deficit exceeding 5° in most of Germany. The abnormal conditions are clearly shown by the isotherm of 30° F., which runs south of New York, north-eastwards to beyond Spitsbergen, then returning almost due south to Switzerland before turning eastwards again. Rainfall nowhere differed greatly from normal except in Portugal, where there was an excess of more than 4 inches.

In North America pressure was abnormally low (995 mb.) over the Aleutian Islands with a steep gradient for westerly winds to the southward. Temperatures were from 5° to 10° F. above normal over most of Canada. No data were received from Australia or New Zealand.

The most notable feature of the weather of the month in the British Isles was the very cold spell from the 17th to the 26th, which was the most severe cold spell experienced since February 1929. During this period temperature remained below freezing point at many places in some areas for several days: Lympne had a maximum of 22° F. on the 20th. Minimum temperatures were correspondingly low during this period, Dalwhinnie having a minimum of 7° F. on the 19th. There was snow locally in the south-east on the 19th and more general and heavier falls on the 20th and 21st causing severe dislocation of road and rail transport over the few days before Christmas.

On the 1st a very deep depression off the north-west of Scotland moved slowly eastwards and associated secondary depressions moved eastward from the west of Ireland on the 2nd; this resulted in widespread gales on the 1st and caused showers in most places on the 1st and 2nd. A ridge of high pressure passed eastward across the British Isles on the 3rd giving good sunshine records on the whole. Secondary depressions moving north-eastwards along the western seaboard, associated with a depression south-west of Iceland, caused heavy rain generally on the 4th but the depression became less intense on the succeeding days; a complex trough of low pressure approaching Ireland from the west on the 7th resulted in heavy rain locally in Ireland and northern Scotland while its passage over the country on the 8th gave some rain in most places. A depression, approaching Ireland from the Atlantic on the 9th, became almost stationary west of Ireland on the 10th and spread north-eastwards on the 11th: there was rainfall generally, which was heavy at times, during this period. The depression which was over the north of Ireland on the 12th moved northwards, and a new disturbance situated over the Atlantic north-west of Ireland on the 13th spread slowly eastwards, giving gales in northern Scotland. The associated trough of low pressure gave moderate to heavy rain in most places.

Subsequently an intense anticyclone situated over Russia extended its influence westwards and by the 17th cold continental air reached the British Isles causing a fall in temperature which became more pronounced by the 18th. Snow fell in all districts at times during this period until about the 25th and was particularly heavy in eastern and south-eastern England.

A ridge of high pressure passed across the British Isles in a south-easterly direction on the 25th and was followed by a trough of low pressure which extended from southern Norway across England and Wales on the 26th. Temperatures rose quite quickly again on the 26th and 27th although in the eastern and south-eastern districts of England there was a further fall of snow on the 26th. A depression to the west of Iceland on the 28th moved eastwards and then south-eastwards on the following days until the end of the month when it was centred over Norway: there was rainfall generally on the 28th and 29th.

Gales were reported on many days during the month, the worst period being the 12th to 18th when Wick and Lerwick reported gales on each of these days.

The distribution of bright sunshine for the month was as follows:—

	Total hrs.	Diff. from average hrs.		Total hrs.	Diff. from average hrs.
Stornoway ..	36	+14	Chester ..	52	+11
Aberdeen ..	37	0	Ross-on-Wye	62	+14
Dublin	59	+13	Falmouth ..	62	+ 9
Birr Castle ..	59	+16	Gorleston ..	47	+ 6
Valentia ..	76	+37	Kew.. ..	50	+13

Kew temperature, mean, 40·3°F.: diff. from average, —1·1°F.

Miscellaneous Notes on Weather Abroad

An unusually severe cold spell began in Siberia on December 9th, 70°—90° of frost were reported in the following week. This cold wave swept across Europe in the middle of the month. Temperatures fell rapidly on the 17th and 18th, 20° of frost being reported from many places in France, and 30° in Germany. Rivers and lakes froze, and navigation and transport were seriously impeded. Snow fell in Switzerland on the 20th, and a slight rise of temperature in western Europe on the 21st was accompanied by snow generally. Trains were delayed, air services interrupted, many schools were closed, and in northern France nearly 18,000 miners and steel workers were unable to work owing to frost damage. Lyons reported 45° of frost on the 22nd. The intense cold spread to northern Italy on the 25th, when Milan reported 19° of frost. In Rome, however, temperatures remained higher, but snow fell on Vesuvius. Heavy snow storms in Rumania caused a serious railway accident on the 24th, in which more than 100 people were killed. After further heavy snow, a thaw set in over western Europe on the 27th, but temperatures remained low in the east, Sopron in Hungary recording 41° of frost. During a typhoon which passed across the Philippines on the 8th, the barometer fell to 28·50 in. at Lugon. Much damage was caused and 19 deaths were reported. Eight people lost their lives in an aeroplane crash in dense fog at Mexico City on the 2nd.

Blizzards swept across the United States from Alaska on the 27th : low temperatures were general and many deaths resulted. All Canada, except British Columbia, also experienced extreme cold, Edmonton registering 51° below zero towards the end of the month. Severe gales caused widespread damage in Victoria and Sydney on the 9th and 10th. Winds frequently reached hurricane force, and fires followed the gale. The damage is estimated at £500,000. (*The Times*, December 3rd–31st, 1938.)

Daily Readings at Kew Observatory, December, 1938

Date	Pressure, M.S.L. 13h.	Wind, Dir., Force 13h.	Temp.		Rel. Hum. 13h.	Rain	Sun	REMARKS
			Min.	Max.				
	mb.		°F.	°F.	%	in.	hrs.	
1	993·8	SW. 4	40	48	66	0·06	4·6	r 6h, prq 14h.
2	1006·3	SW. 4	39	49	76	0·03	4·1	r_0–r 18h.–20h.
3	1015·1	W. 4	40	47	62	—	4·3	f–F 21h.–24h.
4	1018·6	SSE. 2	28	49	82	Trace	0·6	F–f 0h.–11h., d_0 21h.–
5	1008·4	W. 3	49	55	68	0·06	1·4	ir_0–r 1h.–9h. [24h.
6	1015·5	SW. 3	37	50	80	—	1·7	
7	1010·6	S. 3	45	50	74	—	1·6	
8	995·1	SSW. 4	42	51	87	0·05	0·1	ir_0 3h.–9h., d 13h.–
9	998·4	S. 4	34	49	74	0·33	3·5	r–r_0 17h.–24h. [14h.
10	993·5	SSE. 3	48	52	86	0·17	0·1	r_0 0h.–4h., d_0 15h.–
11	995·8	SE. 2	48	53	83	0·02	0·0	ir_0 3h.–8h. [16h.
12	1005·8	SSW. 4	51	54	79	0·05	3·9	ir_0 3h.–7h.
13	1011·7	S. 3	42	52	85	—	0·3	
14	1014·1	SW. 2	49	53	89	0·10	0·0	r_0 2h.–9h., f 19h.–24h.
15	1014·6	S. 3	37	51	84	0·02	1·5	F–f 0h.–12h., r_0 21h.–
16	1014·6	SE. 2	47	49	96	1·03	0·0	r_0–r 4h.–23h. [23h.
17	1025·7	E. 3	42	42	76	Trace	0·0	ir_0 1h.–6h.
18	1023·2	ENE. 6	26	30	58	Trace	3·3	is_0 22h.–24h.
19	1018·6	NE. 4	27	28	81	Trace	0·0	is_0 0h.–14h.
20	1010·4	N. 5	22	27	58	Trace	2·5	s_0 15h.
21	1004·9	N. 2	21	29	92	0·45	0·0	s_0–s 8h.–24h.
22	1007·0	CALM	28	35	92	0·29	0·0	$r_0 s_0$ 13h.–15h. & 18h.–
23	1015·0	SE. 2	30	31	81	0·04	0·0	is_0 0h.–13h. [24h.
24	1020·6	NNE. 4	29	35	83	0·01	0·0	s_0 12h.–15h.
25	1032·3	ENE. 3	32	33	79	Trace	0·0	r_0 s_0 f 13h.
26	1025·8	SSW. 3	29	36	90	0·28	0·0	s_0–s 5h.–13h., d_0 21h.
27	1017·3	NW. 3	35	44	77	—	5·6	
28	1019·4	NW. 2	39	42	75	0·04	2·2	r_0–d_0 f 21h.–24h.
29	1011·2	SW. 2	38	45	96	0·23	0·0	r–r_0 15h.–21h., q 21h.
30	1002·6	W. 4	37	43	71	Trace	3·4	d_0 15h.
31	1006·2	W. 3	33	42	77	0·03	5·1	d_0 7h., d 20h.–21h.
*	1011·4	—	37	44	79	3·29	1·6	*Means or totals.

General Rainfall for December, 1938

England and Wales	121	per cent of the average 1881–1915.
Scotland	84	
Ireland	105	
British Isles ...	109	

Rainfall : December, 1938 : England and Wales

Co.	STATION.	In.	Per cent of Av.	Co.	STATION.	In.	Per cent of Av.
Lond .	Camden Square..........	3·55	149	*War* ·	Birminghm. Edgbaston	4·39	163
Sur .	Reigate, Wray Pk. Rd..	4·01	126	*Leics* .	Thornton Reservoir ...	3·85	144
Kent .	Tenterden, Ashenden...	4·10	132	,, .	Belvoir Castle...........	4·07	165
,, .	Folkestone, I. Hospital.	3·07	...	*Rut* .	Ridlington	3·73	149
,, .	Margate, Cliftonville....	2·19	96	*Lincs* .	Boston, Skirbeck.........	4·43	206
,, .	Eden'bdg., Falconhurst	4·03	122	,, .	Cranwell Aerodrome...	4·13	187
Sus .	Compton, Compton Ho.	3·93	94	,, .	Skegness, Marine Gdns.	2·95	134
,, .	Patching Farm..........	4·00	119	,, .	Louth, Westgate.........	4·40	158
,, .	Eastbourne, Wil. Sq....	3·54	101	,, .	Brigg, Wrawby St.......	4·01	...
Hants.	Ventnor, Roy.Nat.Hos.	3·49	106	*Notts* .	Mansfield, Carr Bank...	4·48	155
,, .	Southampton,East Park	3·97	108	*Derby*.	Derby, The Arboretum	3·68	136
,, .	Ovington Rectory.......	4·78	121	,, .	Buxton, Terrace Slopes	8·26	146
,, .	Sherborne St. John......	3·66	111	*Ches* .	Bidston Obsy.............	3·31	125
Herts .	Royston,Therfield Rec.	3·55	153	*Lancs*.	Manchester, Whit. Pk.	3·56	110
Bucks.	Slough, Upton............	2·88	114	,, .	Stonyhurst College......	5·57	115
Oxf .	Oxford, Radcliffe.........	2·89	117	,, .	Southport, Bedford Pk.	4·02	124
N'hant	Wellingboro, Swanspool	3·73	159	,, .	Ulverston, Poaka Beck	5·82	105
,, .	Oundle	2·84	...	,, .	Lancaster, Greg Obsy.	4·69	108
Beds .	Woburn, Exptl. Farm...	3·47	148	,, .	Blackpool	3·69	113
Cam .	Cambridge, Bot. Gdns.	2·68	139	*Yorks*.	Wath-upon-Dearne......	3·05	129
,, .	March.......................	3·22	153	,, .	Wakefield,Clarence Pk.	3·28	135
Essex .	Chelmsford,County Gdns	2·43	109	,, .	Oughtershaw Hall.......	8·19	...
,, .	Lexden Hill House......	3·13	...	,, .	Wetherby, Ribston H..	4·84	198
Suff .	Haughley House.........	2·28	...	,, .	Hull, Pearson Park......	3·99	166
,, .	Rendlesham Hall........	2·94	125	,, .	Holme-on-Spalding......	4·86	198
,, .	Lowestoft Sec. School...	2·10	90	,, .	Felixkirk, Mt. St. John.	4·46	185
,, .	Bury St. Ed., WestleyH.	2·85	118	,, .	York, Museum............	4·01	179
Norf. .	Wells, Holkham Hall...	3·30	160	,, .	Pickering, Houndgate...	4·50	179
Wilts .	Porton, W.D. Exp'l. Stn	4·30	137	,, .	Scarborough...............	3·36	141
,, .	Bishops Cannings........	3·96	121	,, .	Middlesbrough............	2·87	148
Dor .	Weymouth, Westham.	3·12	90	,, .	Baldersdale, Hury Res.	4·14	112
,, .	Beaminster, East St....	5·25	110	*Durh* .	Ushaw College............	4·65	186
,, .	Shaftesbury...............	3·34	92	*Nor* .	Newcastle, Leazes Pk...	3·62	154
Devon.	Plymouth, The Hoe....	3·77	75	,, .	Bellingham, Highgreen	3·97	109
,, .	Holne, Church Pk. Cott.	8·58	101	,, .	Lilburn Tower Gdns....	3·12	119
,, .	Teignmouth, Den Gdns.	3·26	77	*Cumb*.	Carlisle, Scaleby Hall...	2·95	92
,, .	Cullompton	5·02	114	,, .	Borrowdale, Seathwaite	10·75	70
,, .	Sidmouth, U.D.C.........	3·62	...	,, .	Thirlmere, Dale Head H.	8·67	79
,, .	Barnstaple, N. Dev.Ath	4·02	91	,, .	Keswick, High Hill......	5·31	79
,, .	Dartm'r,Cranmere Pool	10·90	...	,, .	Ravenglass, The Grove	5·28	115
,, .	Okehampton, Uplands.	7·03	100	*West* .	Appleby, Castle Bank...	3·86	97
Corn .	Redruth, Trewirgie......	6·93	111	*Mon* .	Abergavenny, Larchf'd	5·77	129
,, .	Penzance, Morrab Gdns.	4·10	72	*Glam* .	Ystalyfera, Wern Ho....	6·85	82
,, .	St. Austell, Trevarna...	6·14	101	,, .	Treherbert, Tynywaun.	10·19	...
Soms .	Chewton Mendip.........	5·51	102	,, .	Cardiff, Penylan..........	4·38	97
,, .	Long Ashton.............	3·57	92	*Carm* .	Carmarthen,M. & P. Sch.	5·91	99
,, .	Street, Millfield..........	3·59	108	*Card* .	Aberystwyth	3·38	...
Glos .	Blockley	4·16	...	*Rad* .	BirmW.W.Tyrmynydd	7·20	88
,, .	Cirencester, Gwynfa....	3·24	97	*Mont* .	Lake Vyrnwy	6·41	93
Here .	Ross-on-Wye.............	3·83	129	*Flint* .	Sealand Aerodrome......	3·07	125
,, ·	Kington, Lynhales.......	3·22	86	*Mer* .	Blaenau Festiniog	9·26	80
Salop .	Church Stretton.........	4·29	128	,, .	Dolgelley, Bontddu......	6·50	95
,, .	Shifnal, Hatton Grange	2·36	92	*Carn* ·	Llandudno	3·65	126
,, .	Cheswardine Hall........	2·78	99	,, .	Snowdon, L. Llydaw 9..	15·00	...
Worc .	Malvern, Free Library...	3·93	142	*Ang* .	Holyhead, Salt Island...	4·35	105
,, ·	Ombersley, Holt Lock.	3·10	118	,, .	Lligwy	...	...
War .	Alcester, Ragley Hall...	3·29	134	*I. Man*	Douglas, Boro' Cem....	4·30	87

Rainfall: December, 1939: Scotland and Ireland

Co.	STATION.	In.	Per cent of Av.
Guern.	St.Peter P't.Grange Rd.	5·48	134
Wig .	Pt. William, Monreith.	3.99	88
,, .	New Luce School.........	4·73	85
Kirk .	Dalry, Glendarroch......	5·14	72
Dumf.	Eskdalemuir Obs........	4·61	66
Roxb .	Hawick, Wolfelee........	3·46	83
,, .	Kelso, Broomlands......	1·84	79
Peeb .	Stobo Castle.	3·08	81
Berw .	Marchmont House......	2·86	102
E.Lot.	North Berwick Res.....	...	...
Midl .	Edinburgh, Blackfd. H.	2·13	91
Lan .	Auchtyfardle	2·53	...
Ayr .	Kilmarnock, Kay Park	2·22	...
,, .	Girvan, Pinmore.........	4·93	82
,, .	Glen Afton, Ayr San....	5·71	89
Renf .	Glasgow, Queen's Park	2·78	66
,, .	Greenock, Prospect H..	6·73	90
Bute .	Rothesay, Ardencraig...	5·42	99
,, .	Dougarie Lodge.........	3·69	67
Arg .	Loch Sunart, G'dale....	8·92	102
,, .	Ardgour House..........	11·09	...
,, .	Glen Etive................	10·78	88
,, .	Oban......................	6·88	...
,, .	Poltalloch................	6·66	104
,, .	Inveraray Castle.........	8·98	90
,, .	Islay, Eallabus...........	6·50	110
,, .	Mull, Benmore...........	9·30	55
,, .	Tiree	...	...
Kinr .	Loch Leven Sluice.......	3·03	77
Fife .	Leuchars Aerodrome...	2·55	103
Perth .	Loch Dhu.................	9·05	90
,, .	Crieff, Strathearn Hyd.	3·55	79
,, .	Blair Castle Gardens....	3·48	91
Angus.	Kettins School...........	3·83	116
,, .	Pearsie House...........	3·99	...
,, .	Montrose, Sunnyside...	3·25	117
Aber .	Balmoral Castle Gdns..	3·11	92
,, .	Logie Coldstone Sch....	2·57	91
,, .	Aberdeen Observatory.	3·83	119
,, .	New Deer School House	3·30	96
Moray	Gordon Castle...........	1·27	47
,, .	Grantown-on-Spey	1·71	63
Nairn.	Nairn	·97	44
Inv's .	Ben Alder Lodge.........	6·85	...
,, .	Kingussie, The Birches.	2·78	...
,, .	Loch Ness, Foyers	...	...
,, .	Inverness, Culduthel R.	2·06	76
,, .	Loch Quoich, Loan......	12·25	...
,, .	Glenquoich...............	12·49	85
,, .	Arisaig House............	7·84	108
,, .	Glenleven, Corrour......	9·58	104
,, .	Fort William, Glasdrum	9·34	...
,, .	Skye, Dunvegan.........	6·95	...
,, .	Barra, Skallary.........	4·73	...
R&C.	Tain, Ardlarach..........	1·56	50
,, .	Ullapool	4·15	66
,, .	Achnashellach	7·78	77
R&C .	Stornoway,C.GuardStn.	4·41	74
Suth .	Lairg........................	2·94	73
,, .	Skerray Borgie...........	3·09	...
,, .	Melvich.....................	2·96	69
,, .	Loch More, Achfary....	7·45	81
Caith .	Wick	1·96	64
Ork .	Deerness	4.42	106
Shet .	Lerwick Observatory...	4·82	100
Cork .	Cork, University Coll...	...	...
,, .	Roches Point, C.G. Stn.	3·48	65
,, .	Mallow, Longueville....	4·89	100
Kerry.	Valentia Observatory...	5·86	88
,, .	Gearhameen..............	9·00	72
,, .	Bally McElligott Rec...	4·35	...
,, .	Darrynane Abbey.......	4·39	75
Wat .	Waterford, Gortmore...	4·82	105
Tip .	Nenagh, Castle Lough.	4·20	91
,, .	Cashel, Ballinamona....	4·97	116
Lim .	Foynes, Coolnanes......	3·99	84
,, .	Limerick, Mulgrave St..	4·33	93
Clare .	Inagh, Mount Callan....	6·12	...
Wexf .	Gorey, Courtown Ho...	5·94	155
Wick .	Rathnew, Clonmannon.	6·99	...
Carl .	Bagnalstown,Fenagh H.	4·79	127
,, .	Hacketstown Rectory...	6·99	171
Leix .	Blandsfort House.......	4·73	129
Offaly.	Birr Castle................	3·31	101
Kild .	Straffan House...........	2·82	92
Dublin	Dublin, Phoenix Park..	3·00	118
Meath.	Kells, Headfort..........	3·55	93
W.M .	Moate, Coolatore.........	2·92	...
,, .	Mullingar, Belvedere...	2·83	77
Long .	Castle Forbes Gdns......	...	...
Gal .	Galway, Grammar Sch.	3·59	79
,, .	Ballynahinch Castle....	6·45	86
,, .	Ahascragh, Clonbrock.	4·11	87
Rosc .	Strokestown, C'node.....	3·36	90
Mayo.	Blacksod Point..........	4·42	72
,, .	Mallaranny	6·95	...
,, .	Westport House.........	...	...
,, .	Delphi Lodge.............	...	...
Sligo .	Markree Castle..........	5·72	121
Cavan.	Crossdoney, Kevit Cas..	3·95	...
Ferm .	Crom Castle..............	4·00	97
Arm .	Armagh Obsy............	3·35	107
Down.	Fofanny Reservoir......	9.44	...
,, .	Seaforde	5.49	133
,, .	Donaghadee, C. G. Stn.	3.05	96
Antr .	Belfast,Queen's Univ....	4.45	121
,, .	Aldergrove Aerodrome.	3.37	98
,, .	Ballymena, Harryville.	3.98	90
Lon .	Garvagh, Moneydig....	4.73	...
,, .	Londonderry, Creggan.	5.65	129
Tyr .	Omagh, Edenfel.........	5.03	119
Don .	Malin Head..............	4.96	120
,, .	Dunfanaghy..............	4·74	105
,, .	Dunkineely...............	5·56	...

Climatological Table for the British Empire, July, 1938

STATIONS.	PRESSURE.		TEMPERATURE.							Relative Humidity	Mean Cloud Am'nt	PRECIPITATION.			BRIGHT SUNSHINE.	
			Absolute.		Mean Values.				Mean							
	Mean of Day M.S.L.	Diff. from Normal.	Max.	Min.	Max.	Min.	½ Max. and Min.	Diff. from Normal.	Wet Bulb.			Am'nt.	Diff. from Normal.	Days	Hours per day.	Percentage of possible.
	mb.	mb.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	%	0–10	in.	in.			
London, Kew Obsy....	1014·7	− 1·1	81	48	70·0	55·0	62·5	− 0·3	55·3	79	7·5	1·02	− 1·15	8	4·7	29
Gibraltar..................	1016·7	− 0·1	97	61	78·5	65·9	72·2	− 2·6	64·9	80	3·3	0·00	...	0	...	...
Malta........................	1015·5	+ 0·8	92	65	83·1	70·5	76·8	− 1·5	68·9	70	0·4	0·00	− 0·05	0	12·8	90
St. Helena	1019·8	− 1·3	68	53	63·5	56·0	59·7	+ 1·9	57·7	95	8·8	2·59	− 1·48	22	...	...
Freetown, Sierra Leone	1013·8	+ 2·8	86	69	81·5	72·8	77·1	...	73·7	84	8·3	28·91	− 6·67	27	...	...
Lagos, Nigeria	1014·0	+ 0·8	85	66	80·7	72·3	76·5	− 1·5	73·0	89	8·5	3·48	− 7·02	8	3·8	31
Kaduna, Nigeria	1012·4	...	92	65	82·9	68·2	75·5	+ 1·3	70·0	88	9·0	7·30	− 3·32	20	4·5	36
Zomba, Nyasaland	1017·9	− 0·7	84	50	73·3	54·9	64·1	+ 2·1	60·7	79	5·3	0·00	− 0·35	0	...	...
Salisbury, Rhodesia...	1020·6	− 1·0	77	35	69·5	43·5	56·5	+ 0·4	48·5	56	3·3	0·02	...	1	7·8	70
Cape Town	1021·1	− 0·2	79	40	65·3	49·5	57·4	+ 2·7	51·0	92	5·3	2·72	− 0·90	17	...	...
Johannesburg	1022·0	− 1·0	69	33	60·6	41·5	51·1	+ 0·7	41·3	54	2·6	0·20	− 0·13	3	8·6	80
Mauritius	1020·2	− 0·3	78	52	74·8	63·3	69·1	+ 0·8	65·5	75	5·5	1·79	− 0·49	18	6·4	58
Calcutta, Alipore Obsy.	999·8	+ 0·6	94	77	89·5	79·6	84·5	+ 0·8	79·9	88	9·2	6·11	− 6·59	14*	...	...
Bombay	1003·8	− 0·1	88	72	85·2	76·3	80·7	− 0·7	77·4	87	9·3	16·06	− 8·21	26*	...	...
Madras	1003·9	− 0·6	99	75	95·5	79·5	87·5	− 0·1	74·6	64	8·7	1·96	− 1·88	7*	...	...
Colombo, Ceylon	1008·9	− 0·2	86	73	84·4	76·8	80·6	− 0·6	76·3	76	7·8	4·10	− 0·33	13	5·7	46
Singapore	1008·9	0·0	90	71	86·4	76·5	81·5	+ 0·2	77·4	77	6·3	6·21	− 0·58	12	7·6	62
Hongkong................	1006·1	+ 1·4	94	76	87·4	79·0	83·2	+ 0·7	78·9	81	7·2	12·23	− 2·19	21	6·6	50
Sandakan	1008·6	...	89	72	86·9	74·8	80·9	− 0·9	76·3	85	7·7	10·63	+ 3·91	16	...	...
Sydney, N.S.W..........	1018·3	0·0	70	39	61·1	44·5	52·8	+ 0·1	46·7	74	4·5	2·92	− 1·88	15	5·5	54
Melbourne	1019·6	+ 0·7	61	34	56·1	40·8	48·5	− 0·2	42·8	86	6·9	2·24	+ 0·38	17	3·1	32
Adelaide	1020·3	+ 0·1	66	39	60·0	44·7	52·3	+ 0·4	48·1	77	6·4	1·88	− 0·76	16	3·8	38
Perth, W. Australia ...	1017·7	− 1·3	70	43	63·6	48·7	56·1	+ 0·9	50·9	73	6·0	5·42	− 1·14	17	5·6	55
Coolgardie	1019·9	0·0	75	36	59·5	43·1	51·3	+ 0·1	46·6	76	5·5	2·41	+ 1·54	12	...	...
Brisbane..................	1018·5	+ 0·1	73	45	65·6	50·3	57·9	− 0·6	51·6	74	5·1	1·43	− 0·77	12	6·1	58
Hobart, Tasmania......	1019·8	+ 6·1	55	34	50·8	38·6	44·7	− 1·0	40·6	85	7·4	3·78	+ 1·60	14	3·6	38
Wellington, N.Z.	1013·1	− 0·8	57	33	49·4	40·7	45·1	− 2·9	42·8	81	7·8	4·69	− 0·94	23	3·1	33
Suva, Fiji	1013·8	− 0·2	88	62	81·5	69·5	75·5	+ 2·1	71·0	86	4·4	14·32	+ 9·39	17	5·5	49
Apia, Samoa	1012·2	+ 0·3	87	72	84·8	75·4	80·1	+ 2·9	79·6	93	4·5	5·86	+ 2·88	17	9·4	82
Kingston, Jamaica	1014·5	− 0·2	92	71	88·8	73·5	81·1	− 0·6	71·7	74	3·9	0·62	− 1·00	6	7·0	53
Grenada, W.I.	1011·4	− 1·9	89	70	86	73	79·5	+ 0·3	73	74	6	10·09	+ 0·66	18	...	...
Toronto..................	1014·0	− 0·4	92	53	81·4	62·2	71·8	+ 2·7	63·8	78	5·5	2·62	− 0·22	12	8·3	55
Winnipeg	1012·6	+ 0·3	93	48	79·4	57·7	68·5	+ 2·1	58·0	87	5·6	4·08	+ 0·98	18	8·3	52
St. John, N.B.	1015·1	+ 1·5	80	50	66·8	54·0	60·4	0·0	57·7	92	8·2	6·40	+ 2·77	21	4·1	27
Victoria, B.C............	1017·6	+ 0·3	84	47	68·9	52·3	60·6	+ 0·5	55·4	76	2·8	0·41	− 0·01	5	10·8	69